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MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. LII NOVEMBER–DECEMBER, 1960 NO. 6

STUDIES IN USTILAGINALES

4. MORPHOLOGY AND CYTOLOGY OF TILLETIA ELEUSINES ON ELEUSINE VERTICILLATA

N. C. JOSHI[1]

(WITH 18 FIGURES)

While studying some genera, *Entyloma, Melanotaenium* and *Tilletia* of the order Ustilaginales, I came across a species of *Tilletia, T. eleusines* Syd., on *Eleusine verticillata* Roxb. in Ajmer (**8**). Though *Tilletia* has been studied by Fischer von Waldheim (**5**), Wolff (**18**), McAlpine (**13**), Dastur (**4**), Tang (**16**) and Das (**3**) who have worked out the life history of many species, there is no record of a detailed study of *T. eleusines*. Investigations were undertaken to work out the morphological and cytological details of this species.

MATERIALS AND METHODS

Young smutted plants of *Eleusine verticillata* were collected from Todgargh in Ajmer district. They were placed in cellophane bags after exposure for 24 hours in the sun. The teliospores were placed for germination in different solid and liquid media. When the required stages of the germination were reached, they were fixed in FAA, Flemming's weak solution or Karpechenko's fixative. The material fixed in Flemming's solution was bleached with hydrogen peroxide for

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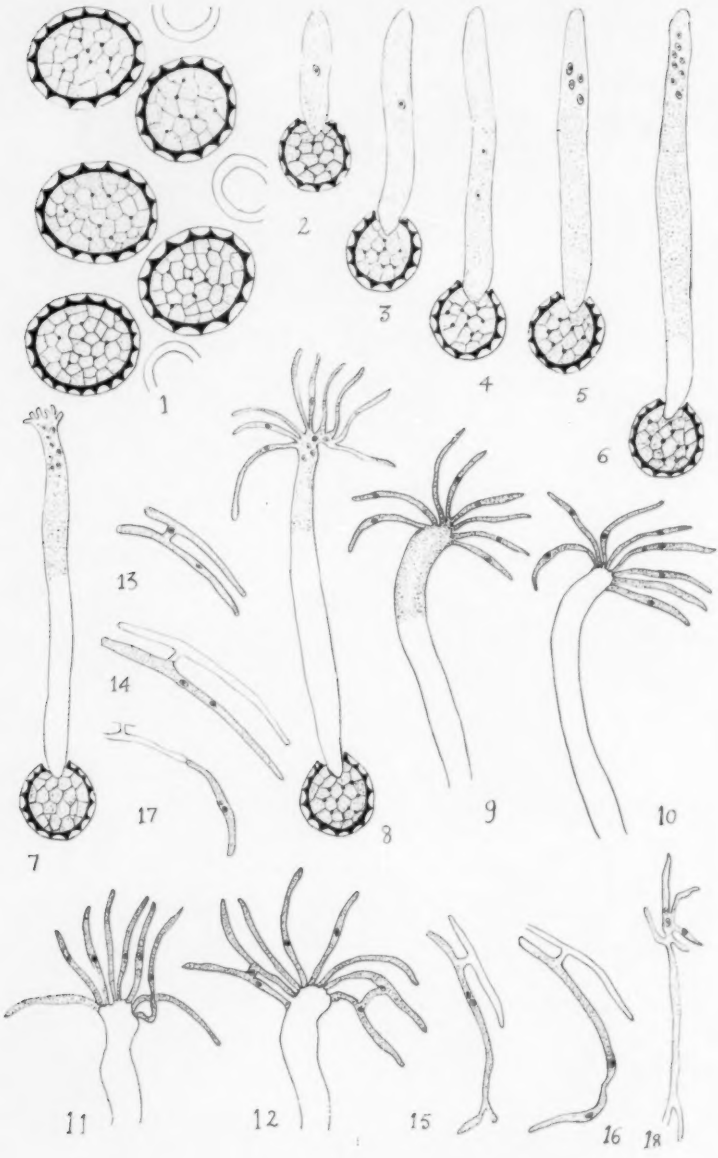

FIGS. 1–18.

20 minutes and stained with iron alum haemotoxylin. In order to study the nuclear condition of the parasitic mycelium and the development of teliospores in the host tissue, the infected stems of various stages were fixed in FAA, acetic alcohol, Navashin A and B. Microtome sections of 6–12 μ thickness were cut, bleached with hydrogen peroxide and stained with iron alum haemotoxylin, Bismark brown, Gentian violet and Flemming's triple stain which gave the best results.

RESULTS

MORPHOLOGY. The sori of *Tilletia eleusines* which are mainly found in the ovaries of *Eleusine verticillata* are scattered in the spike replacing the seeds completely and are enclosed in the pericarp. Their shapes are oblong and lengths vary from 1.5–2.5 mm. They are partly concealed by the glumes. The spore mass is black; the teliospores are brown, globose, 17–25 μ in diameter, with a mean of 19 μ (FIG. 1). The epispore is 2–5 μ in thickness with prominent reticulations. The sterile cells are hyaline, smooth, 9–11 μ in diameter. The epispore is 2–2.5 μ in thickness (FIG. 1).

HISTOPATHOLOGY. The nucleus of the healthy cells of *Eleusine verticillata* is round and there are two or three deeply stained nucleoli. The general organization of the cells of the host maintains their healthy condition though the hyphae are distributed in the intercellular spaces. Marked changes take place in the cells of the infected ovary. The hyphae are intercellular. The leucoplast of the infected cells becomes pale and smaller in size and later disappears. The cell wall later rup-

FIGS. 1–18. *Tilletia eleusines*. FIG. 1. Mature teliospores with sterile hyaline cells, × 1200. FIG. 2. Early germinating stages of the spore with single diploid nucleus in the promycelium, × 1200. FIG. 3. Spores giving rise to the promycelium with a single nucleus and vacuole, × 1200. FIG. 4. The first division of the nucleus in the promycelium, × 1200. FIG. 5. The second division of the nucleus giving rise to 4 nuclei, × 1200. FIG. 6. The third division of the nucleus giving rise to 8 nuclei, × 1200. FIG. 7. Appearance of the projections at the tip of the promycelium, × 1200. FIG. 8. Development of the sporidia which are eight in number, × 1200. FIG. 9. Migration of one nucleus into each sporidium, × 1200. FIG. 10. Development of the septa at the lower region of sporidia, × 1200. FIG. 11. Formation of vacuole in the sporidia, × 1200. FIG. 12. Conjugating sporidia, × 1200. FIG. 13. Migration of the nucleus of one sporidium into the other, × 1200. FIG. 14. Migration of protoplasm from one sporidium into the other, × 1200. FIG. 15. Appearance of the projections at the end of the primary sporidia, × 1200. FIG. 17. Secondary sporidium showing binucleate nature, × 1200. FIG. 18. Appearance of the hyphae from the secondary sporidium, × 1200.

tures and ultimately the hyphae enter and the whole ovarian cavity is replaced by the teliospores.

GERMINATION OF TELIOSPORES. Many kinds of solid and liquid media were employed. At a temperature of 19–21° C no teliospores germinated on the following liquid media: 5% glucose solution; 5% lactose solution; distilled water; yeast extract; tap water; 1.5% asparagine. Various solid media, i.e., potato-dextrose agar, glucose agar, Czapek's medium and oatmeal agar, were employed in order to see the germination and growth characters of the fungus. The majority of them did not yield satisfactory results. One per cent glucose agar was the best medium for germination, but even in this medium the germination was scarce and scanty. About 50 to 60 per cent of the spores germinated when they were kept at room temperature before treating the spores with bleaching powder and incubating them at 5 to 8° C for a week.

DEVELOPMENT OF TELIOSPORES IN THE HOST TISSUE. Spore formation in *Tilletia* was first studied by Fischer von Waldheim (**5**) in *T. olida* (Riess) Wint. Development of teliospores in the host was described by Wang (**17**) in *T. caries* (DC.) Tul. Infected host parts, stem and ovary, were fixed in FAA. The L.S. and T.S. of the stem showed the intercellular spaces of the parenchymatous cells infected with branched vegetative hyphae dispersed here and there in the host tissue. The thickness of the hyphae, which are binucleate to multinucleate, varied from 1.5 to 2 μ. At the time of development of the teliospores the ends of the hyphae enlarge, become swollen and more protoplasm accumulates in the swelling. In the earlier stages the swollen portion has two nuclei. Soon after, they come close together and fusion takes place. The walls of the spores become more prominent and one or two vacuoles may develop. In the mature spores the reticulations in the walls become more prominent and the color changes to dark brown. The spores found in the central region of the ovary are mature while at the periphery they are immature.

CYTOLOGY OF THE FUNGUS. The cytology of spore germination in *Tilletia* has been studied by Wolff (**18**) on *T. foetida* (Wallr.) Liro, Brefeld (**1**) on *T. decipiens* (Pers.) Körn., McAlpine (**13**) on *T. fusca* Ell. & Ev., Tang (**16**) on *T. horrida* Tak., Dangeard (**2**), Harper (**7**), Lutman (**11**), Paravicini (**14**), Rawitscher (**15**), Dastur (**4**), Kharbush (**10**) and Wang (**17**) on *T. caries* and *T. foetida*.

The teliospores of *T. eleusines*, like others of *Tilletia*, have a diploid nucleus which is prominent and is found at the center with one or two

vacuoles. In the first stage of germination there is the rupturing of the exosporium and the appearance of a tube, the promycelium (FIG. 2), like that in *T. caries* (**2**, **4**), and *T. holci* (**3**). The migration of the nucleus into the promycelium is immediate (FIG. 2). The promycelium soon increases in length but the breadth is more or less constant. The mature promycelium measures 6–9 μ in width and 80–110 μ in length. The promycelium is unbranched. The nucleus now gradually comes near the center of the promycelium (FIG. 3). A vacuole is seen at the apical end of the promycelium (FIG. 3).

The first division of the nucleus takes place in the promycelium (FIG. 4) like that in *T. caries* (**2**, **4**) and *T. holci* (**3**). The nuclei migrate towards the apical region of the promycelium and then the second division takes place (FIG. 5). The nuclei divide again and thus eight nuclei are formed (FIG. 6) and simultaneously the vacuoles also disappear (FIG. 6). All the nuclei migrate to the tip of the promycelium (FIG. 7) and gradually the protoplasmic contents move towards the tip leaving an empty space behind (FIG. 7). After the division of the nuclei, small projections appear at the tip (FIG. 7). They become elongated and are slender and measure 30–60 × 2–3 μ (FIG. 8). In early stages the sporidia are without nuclei. The sporidia are borne on 8 small protuberances as observed in other species by Dastur (**4**) and Paravicini (**14**). Soon after the migration of the haploid nuclei, a single nucleus goes into each sporidium (FIG. 9). In this case the number of haploid nuclei corresponds to the number of primary sporidia. All the sporidia are at first in direct continuation with the promycelium as in *T. caries* (**4**). The sporidia are later cut off from the promycelium by the septa (FIG. 10). The contents of the sporidia are dense and granular but after the migration of the nuclei they become vacuolated (FIG. 11). The sporidia are eight in number and are uninucleate. The nucleus is globular and does not go beyond the center of the sporidium. Pairing of sporidia soon takes place, when they are still attached to the promycelium (FIG. 12). The conjugation tube is developed in the lower region of the sporidium (FIG. 12). The nuclei of the conjugating pairs proceed towards the connecting bridge (FIG. 13) and the nucleus of one fuses with the other (FIG. 14). Simultaneously the cytoplasm of one travels into the other sporidium (FIG. 14). The empty sporidium now shrivels (FIG. 15) and becomes detached from the other. The empty sporidium in this case does not develop a septum as in *T. holci* (**3**) and *T. caries* (**4**). Afterward a small protuberance arises at the tip of the primary sporidium (FIG. 15). This elongates to develop into a secondary sporidium. The contents of the primary sporidia move

to the secondary sporidium (FIG. 16). The secondary sporidia are binucleate (FIG. 17) like those in *T. caries* (**10**, **14**, **15**). The secondary sporidium now becomes detached from the primary sporidium and gives rise to the hyphae (FIG. 18) which later become branched. The nuclei of the secondary sporidium migrate into the hyphae (FIG. 18) and continue to maintain the binucleate condition. The hyphae are therefore binucleate and thus these observations agree with those of Paravicini (**14**), Rawitscher (**15**) and Maire (**12**) on *T. caries*.

DISCUSSION

The life history of *Tilletia eleusines* very much resembles that of *T. caries* (**2**, **4**) with minor variations. Like *T. caries* (**2**) and *Entyloma dahliae* H. & P. Syd. (**9**), the diploid nucleus of the teliospore migrates into the promycelium. On the other hand Rawitscher (**15**) and Paravicini (**14**) think that in *T. caries* the division of the diploid nucleus takes place in the spore. As soon as the promycelium is formed, a vacuole is also noticed like that in *T. caries* (**4**). The projections at the tip of the promycelium in *T. eleusines* only appear when the nuclear division is complete, as in *T. holci* (**3**). The number of projections which later bear sporidia corresponds to the nuclear divisions and in this respect it resembles very much *T. caries* (**14**). The young sporidia which are developed at the tip of the promycelium are without nuclei, thus differing from *T. caries* (**14**) where the sporidia are nucleated even at a very young stage, and in this respect the author agrees with Rawitscher (**15**) who thinks that the sporidia in *T. caries* are anucleate in an early stage.

In *Tilletia eleusines*, as in *T. caries* (**15**) and *T. holci* (**3**), the primary sporidia fuse in pairs and the nucleus of one sporidium migrates into the other, giving rise to binucleate sporidia. After conjugation, secondary sporidia are formed which are binucleate as in *T. holci* (**3**) but unlike those in *T. caries* and *T. foetida* (**6**) where they are uninucleate. The contents of the sporidia are dense and homogeneous. Later vacuolations appear as in *T. caries* (**4**). The secondary sporidia give rise directly to the dicaryotic hyphae and the author agrees with Maire (**12**), Paravicini (**14**), Rawitscher (**15**) and Dastur (**4**) who observed that the hyphal cells are dicaryotic and are produced by secondary sporidia. The teliospores are found in the intercellular spaces of the ovaries, as in *T. holci* (**3**) and in *Tilletia* sp. (**17**). The two nuclei of the spores fuse at a very early stage and form a diploid nucleus; later the wall becomes deeply reticulate and thick as in *T. caries* (**4**).

SUMMARY

Tilletia eleusines Syd. has been collected in the ovaries of *Eleusine verticillata* from Ajmer.

The spore mass is brownish black and the teliospores are yellowish brown with reticulations on the epispore. The mature teliospores are diploid. About 50 to 60 per cent of the spores germinated when they were kept at room temperature before treating the spores with bleaching powder and incubating them at 5 to 8° C for a week.

The spore on germination gives rise to a long aseptate promycelium bearing 8 sporidia at the tip.

The first division of the nucleus takes place in the promycelium and is followed by second and third divisions giving rise to 8 nuclei.

A single nucleus goes into each sporidium. The fusion between the primary sporidia is accompanied by a short conjugating bridge. The nucleus of one fuses with the other.

The primary binucleate sporidia give rise directly to secondary binucleate sporidia which on germination give rise to dicaryotic hyphae and mycelium.

The parasitic mycelium in the host tissue is branched, septate and the hyphal cells are binucleate.

At the time of teliospore formation, the end cells of the hyphae swell, become globular, fusion of the nuclei takes place, and ultimately form teliospores. At maturity the reticulation on the epispore becomes prominent. The teliospores are found exclusively in the ovaries.

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CHANGING CONCEPTS OF GYMNOSPORANGIUM [1]

FRANK D. KERN

(WITH 1 FIGURE)

Gymnosporangium, as the name of an important genus of the Uredinales, has been in mycological literature since 1805 when it was described by A. P. DeCandolle in the Flora Francaise (Lamarck and Candolle, **1805**). The origin of the name *Gymnosporangium* is an unpublished manuscript by Hedwig f. from which it was adopted by DeCandolle. There is some evidence to show that Hedwig first considered *Gymnospermium* but changed *e* to *o* and *m* to *ang* thus making the spelling *Gymnosporangium* (FIG. 1). Some species, now included in *Gymnosporangium*, at times have been referred to various other genera—*Puccinia* by Micheli, *Aecidium* by Persoon, *Podisoma* by Link, *Hamaspora* by Koern, *Gymnotelium* by Sydow.

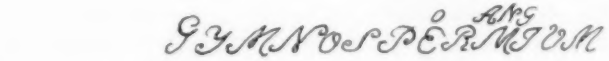

FIG. 1. Copy from an illustration in Hedwig's manuscript, showing how the name *Gymnosporangium* was derived from *Gymnospermium*.

DeCandolle (**1805**) described three species: *G. conicum* Hedw.; *G. fuscum* DC., and *G. clavariaeforme* (Jacq.) DC. *G. conicum* is ambiguous (capable of being applied to more than one species) and must be rejected. The choice of *G. fuscum* as the type species is appropriate, although it is more widely known under the prestarting point specific name of *G. sabinae* (Dickson, **1785**). It is the species used by Oersted (**1865**) in cultural experiments proving that a telial stage on juniper and an aecial stage on pear were phases in the life-history of the same organism.

The characters of *Gymnosporangium* which impressed DeCandolle were the naked gelatinous masses (gymnosporanges), the 2-celled spores

[1] Read before Section 4, Mycology, IX International Botanical Congress, Montreal, Canada, August 20, 1959. Contribution No. 255, Department of Botany and Plant Pathology, The Pennsylvania State University; Abstract, Proc. IX International Botanical Congress **2**: 189. 1959.

(pericarps) at the summit of filaments (pedicelles) which traverse the gelatinous mass, and the occurrence always on the bark of different species of junipers. The concept in general was not erroneous only inadequate; several species are now known in which the teliospores have more than two cells, 3–4, or even 5 or 6 cells (*G. biseptatum, G. ellisii, G. libocedri, G. speciosum*). One species is known in which there are only one-celled spores (*G. tsingchensis*).

It was a matter of early observation that the number and position of the germ-pores in each cell of the teliospores varied but in general there were two near the septa. One pore in each cell, apical in the upper and near the pedicel in the lower, seemed to be the usual arrangement in one species (*G. clavipes*) and later was observed also in another (*G. inconspicuum*). A very striking exception to the rule is found in a species having 5–7 scattered pores in each cell (*G. multiporum*) (Kern, **1909**). Another equally remarkable arrangement is that of 4 pores (sometimes 3 or 5) in a band near the septum but separated from it, with or without 1 or 2 additional, above in the upper, below in the latter (*G. atlanticum*) (Guyot and Malençon, **1957**). Some species differ from others in having hyaline papillae, or thickenings over the germ-pores. Teliospore-walls are usually uniform but in a few species are thicker above. Most and possibly all species have teliospores of two kinds differing more or less in form and color. The lighter colored spores are thin-walled, usually more slender and occur within the gelatinous mass; the darker thick-walled spores are more compact and occur toward the surface of the sori. As long ago as 1889 Plowright said, "The dark spores are the least abundant, and do not germinate so soon as the paler ones do, although they do so within a comparatively short period" (Plowright, **1889**, p. 232). At least two species (*G. clavipes* and *G. inconspicuum*) have swollen pedicels (carotiform). The gelatinization of the pedicels of the teliospores is a characteristic feature of the genus.

A most important advance regarding *Gymnosporangium* was the cultural proof by Oersted (**1865**) that the telial stages on *Juniperus* and the elongated aecial stages on Pomeae (pears, mountain ashes, hawthorns, etc.), then placed in the genus *Roestelia*, were connected. Within a period of two or three years Oersted (**1866**, **1867**) went so far "as to connect each of three species of *Gymnosporangium* found in Denmark with a particular species of *Roestelia*" (*G. fuscum* with *R. cancellata* on pear; *G. cornutum* with *R. cornuta* on mountain ash; *G. clavariiforme* with *R. lacerata* on hawthorn).

Oersted's work established not only a trend but a pattern. *Gymno-*

sporangium had certain characters, so did *Roestelia,* and the two belonged together. *Roestelia* had a restricted host range—not species of one genus like *Gymnosporangium,* but species of closely related genera, members of the tribe Pomeae or family Malaceae (depending upon the classification used). The characters of *Roestelia* which drew attention were the elongated cylindrical, cornute, or flask-shaped peridia and the aeciospores with brownish walls and numerous scattered pores. Later it was recognized that the mature form and condition of the peridium varied in different species. In some species the tubular or cornute form persisted, not much altered by dehiscence which might take place at the apex with slits along the sides; or dehiscence might result in a loss of the tubular form, the sides becoming deeply lacerate or fimbriate, even revolute. It was not long before the microscopic structure of the peridial cells became recognized as important. Fischer (**1891**, p. *272*) pointed out that the peridial cells had different sculptures on the sidewalls, in some, roundish warts; in others, longer or shorter oblique ridges. Later, Fischer (**1895**) elaborated his observations on the peridial cells. Some years earlier Farlow (**1880**) made some observations on peridial cells but did not make descriptions in any detail. He did, however, point out that in two species (*Roestelia botryapites* and *R. hyalina*) the walls of the peridial cells were smooth.

The concept growing out of Oersted's culture work, viz., that the juniper rusts of the genus *Gymnosporangium* had as their aecial stages the *Roestelia*-like forms on various Pomeae became so well established that the possibility of exceptions was slow in developing. In fact the genus was about a hundred years old when the first exception was proved in 1908 (Arthur, **1909**). For many years the basis for such a discovery was in existence but had remained unrecognized.

In 1884 a collection of aecia on *Gillenia stipulacea* was made at Perryville, Missouri, and distributed under the name of *Roestelia lacerata* as No. 3323 in Rabenhorst-Winter, Fungi europaei. This certainly looked like a species of *Roestelia,* and someone put that name on it. No attention seems to have been given to this specimen and its implications until my studies in the winter of 1907–08. At that time it was decided that this must be a genuine *Roestelia* even though it were "off limits" hostwise—Roseae instead of Pomeae. I proposed that a new species of *Gymnosporangium* should be discovered as its alternate stage. "They said it couldn't be done." My associates said that only rusts on Pomeae were related to the rusts on junipers. But field explorations in the vicinity of Mammoth Cave, Kentucky, revealed a new form of *Gymnosporangium* on juniper and subsequent cultures confirmed the

inferences from the structural studies and field work. This was named *Gymnosporangium exterum* Arth. and Kern (Arthur, **1909**).

It was not long before another extralimital connection was proved. This connection was especially notable as it carried the aecial hosts of *Gymnosporangium* outside the tribes Pomeae and Spiraeae of the family Rosaceae into the family Hydrangiaceae. As early as 1906 E. Bethel (**1911**) suspected that an aecial form on *Philadelphus* (family Hydrangiaceae) might be a species of *Roestelia*. The elongated peridium, with cells loosely joined and having characteristic sculpturing on the inner and side walls, and aeciospores with evident germ-pores, supported the theory. Field observations revealed the presence of *Gymnosporangium speciosum* on species of *Juniperus* in close proximity to the *Aecidium gracilens* on *Philadelphus*. A study of the distribution—central Colorado to New Mexico and Arizona—was found to be the same. Cultures in 1911 proved the relationship (Arthur, **1912**).

Long and Gooding (**1939**) described *Gymnosporangium vauqueliniae* with telia on *Juniperus monosperma* and aecia on *Vauquelinia californica* from Arizona. No cultures are reported but the conclusion based on field observations that the two stages are connected seems justified. *Vauquelinia* is classed in the tribe Spiraeae of the Rosaceae.

We have now recorded three instances of Gymnosporangial connections to aecial hosts outside the Pomeae but where the aecial structures are typical, i.e., roestelioid. We have now to record an instance of a connection where the hosts are typical, i.e., Pomeae, but the structures of the aecia are not typical, not roestelioid but aecidioid or cupulate. This is the case of *Gymnosporangium libocedri* on *Libocedrus* with its aecia on different Pomeae (*Amelanchier, Crataegus, Cydonia, Malus, Pyrus,* and *Sorbus*). Cultures were reported by Arthur (**1909**).

Now we come to a combination of these extralimital characters—aecial hosts are not pomaceous and the structures are not of the roestelioid type. This is the connection between *Gymnosporangium ellisii* on *Chamaecyparis* and *Aecidium myricatum* on species of *Myrica* and *Comptonia*. Here we have hosts of not only a new family but of a new order. The tribes Pomeae and Spiraeae and the family Hydrangiaceae are all included in the order Rosales. *Myrica* and *Comptonia* are in the family Myricaceae, order Myricales. The discovery of this connection is described by Fromme (**1914**) and a further report of cultures is made by Arthur (**1915**). Morphological studies and field observations on the association of hosts were largely responsible for the establishment of this connection. Of course, familiarity with the other developments going on in the genus *Gymnosporangium* were most helpful. It

is interesting to note that Farlow (**1885**) once suggested that the aecial form of *G. ellisii* might be found on a host of some order other than Pomaceae. This occurred to him because he could not get spermogonia from sowings of *G. ellisii* on Pomaceae, and in the cedar swamps where *G. ellisii* was found, *Nesaea* was common and not infrequently infested with *Aecidium nesaeae* Gerard. No spermogonia developed here either. Now we know that these aecia belong to a *Carex* rust. His surmise was correct but his conjecture was not a good one.

There is another species with aecidioid aecia on the Pomeae. This is on *Malus, Pyrus,* and *Sorbus* in Alaska, Washington, and Oregon and was named *Aecidium sorbi* by Arthur (**1906**). From this same region on uredo-form was described by Trelease (**1904**, p. 36) on *Chamaecyparis* under the name of *Uredo nootkatensis.* While studying this species, it seemed to me probable that this should have a telial stage like *Gymnosporangium* and that the life-cycle might include *Aecidium sorbi* (Kern, **1908**, **1910**). A few years later Arthur (**1916**) reported the finding of teliospores and commented that my prediction based on "inferences drawn from analogy, homology and geographic distribution" was strengthened. In any event this discovery of teliospores made certain that there was a species of *Gymnosporangium* with a uredo-stage.

This species named *Gymnosporangium nootkatense* (Trel.) Arth. was taken as the type species of a new genus, *Gymnotelium,* by Sydow (**1921**). His characterization of the new genus consisted merely of a statement that it was like *Gymnosporangium,* but with a typical uredo-generation. Hara (**1917**) observed a 1-celled spore-form associated with a Japenese species, *Gymnosporangium haraeanum* on *Juniperus chinensis,* which he regarded as a rudimentary uredo-stage. Hiratsuka (**1937**) provisionally accepts Hara's opinion pointing out that the function of this so-called uredospore-form has never been cleared. Hara (**1927**) treated the species as a member of Sydow's genus *Gymnotelium.* Since the genus *Gymnotelium* was based solely on a difference in life-cycle, its validity has not been generally accepted. However, we do have another species of *Gymnosporangium* with an undoubted uredo-stage. It is described by Zogg (**1949**) as *G. gaeumanni* on *Juniperus nana* from Switzerland. Telial sori were not found but teliospores were intermixed with the uredospores. No aecial stage is known. It seems safe to say one must exist.[2]

No account of the unusual aecial stages of *Gymnosporangium* would

[2] There is still another species with a uredo-stage. It is in Viet-Nam on *Libocedrus,* discovered by Prof. G. Viennot-Bourgin, and described as *Gymnosporangium paraphysatum* Viennot-Bourgin (Rev. Mycol. Paris **25**: 304. 1960).

be complete without reference to *G. bermudianum* which has its aecia on galls on *Juniperus*. These aecia are roestelioid so there is no variation in structure but to have an autoecious species, when all the others are heteroecious, is a noteworthy feature. The *Roestelia* on *Juniperus* was described by Farlow (**1887**) and the life-history of the species was established by Earle (**1893**).

The growth of the genus, if we may use that expression, was slow. Seventy-five years after its founding Farlow (**1880**) in an important paper said, "The species of the genus are comparatively few in number." He mentioned eight species as occurring in the United States but thought the validity of two of them questionable. He listed also eight species of *Roestelia* and experimented with the task of tracing the connection between them and the species of *Gymnosporangium* but with no success.

When Dietel (**1900**, p. 50) contributed the account of the Uredinales to Die natürlichen Pflanzenfamilien, he reported 14 species of Gymnosporangium, 5 in Europe, 8 in North America, 1 in Asia (Himalayi). He said the aecial stages had been called *Roestelia* and were exclusively on the Pomaceae.

In 1911 when I published a taxonomic paper (Kern, **1911**) on the genus, I included 40 species. Of this number 7 were known only in the form genus *Roestelia* at that time and it was more or less misleading to include them in *Gymnosporangium*. All of them, however, have been subsequently connected to telial stages in the genus.

The Sydows (**1915**) in the *Monographia uredinearum* reported 43 species of *Gymnosporangium*, with aecia and telia 28 species, with teliospores only 6 species, with aecia only 9 species, distributed as follows: Europe, 8; Asia, 9; North Africa, 1; America, 32.

Dietel (**1928**) in his revised account for the Pflanzenfamilien said there were 40 species in the northern hemisphere, especially numerous in North America.

Crowell (**1940**), in a paper on the geographic distribution of the genus *Gymnosporangium*, said the genus is composed of about 48 species. This is apparently the total number for which he recognized telial or aecial stages.

The number of species in a genus must vary from time to time and will vary also from one worker to another. There are instances when it is an open question whether two names really represent two good species or whether only one species is involved, thus making one name a synonym. Reducing names to synonymy, or recognizing them as valid, affects the count. It does not subtract or add to what exists in nature but it does subtract or add to what some one recognizes as existing.

The latest studies of the writer accounts for 55 species with telia. Of these there are 12 with aecial stages unknown, but it seems certain that they must exist. In addition there are 11 aecial stages on Pomeae which without much doubt are connected to telial stages of *Gymnosporangium*. Some of these unattached telia may be connected with some of the unattached aecia but for the most part observations for conjectures are lacking. Field studies are necessary for working hypotheses and cultures for proof. It should not be overlooked that more aecial stages outside the Pomeae may be discovered.

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GROWTH STUDIES OF NOCARDIA SPECIES. I. RESPIRATION OF CARBOHYDRATES BY NOCARDIA RUBRA [1]

NORVEL M. MCCLUNG, JOSEPHINE SEE SALSER, AND THOMAS SANTORO

(WITH 6 FIGURES)

Earlier studies on the metabolism of carbon compounds by different species and strains of *Nocardia* showed distinct qualitative differences in the patterns of utilization of a spectrum of some 40 test compounds (McClung, **1954a**). However, these observed differences appeared completely random in character and could not be correlated with proposed morphological groups (McClung, **1949**). Variations were found to exist even with different strains of a single species, e.g., six isolates of *N. asteroides* (McClung, **1954a**). In order to determine whether or not a clearer picture of the pattern of carbon metabolism in *Nocardia* species might be gained by a quantitative evaluation of differences, the current studies were made.

MATERIALS AND METHODS

Nocardia rubra (received as *Proactinomyces ruber* (Casabó) Bald. from Centraalbureau voor Schimmelcultures) was used throughout these experiments. Stock cultures were routinely maintained on glycerol nutrient agar slants, stored at 4° C after an initial incubation at room temperatures for two weeks.

Respiration studies. The organism was grown in the following liquid medium: glucose, 10 g; $NaNO_3$, 4 g; K_2HPO_4 (anhydrous), 0.8 g; $MgSO_4 \cdot 7H_2O$, 0.5 g; $Fe_2(SO_4)_3$, 10 mg; $MnCl_2 \cdot 4H_2O$, 8 mg; $ZnSO_4 \cdot H_2O$, 2 mg; thiamine, 0.1 mg; biotin, 0.12 mg; demineralized water [2] to make one liter. This basal medium was adjusted to pH 7.0–7.2, and 250 ml lots were dispensed into 800 ml flasks and autoclaved.

[1] These studies were made possible by a grant from the General Research fund, University of Kansas and the National Institute of Allergy and Infectious Diseases, Public Health Service (research grant No. E-2075).

[2] Distilled water was passed through a Barnstead demineralizer so that the final concentration of ions was less than 0.2 ppm.

Inocula were prepared as described by McClung (**1954a**) and cultures were incubated at room temperatures on a reciprocating shaker. After 6–7 days incubation (4 days, for the cultures used in the studies with mixed carbon sources), the cells were harvested by centrifugation, washed twice with sterile distilled water and finally resuspended to give a relatively uniform suspension containing about 8–10 mg/ml on a dry weight basis. Such a suspension could be kept for 10–14 days at 4° C without appreciable loss of activity.

Respiration studies were carried out at 28° using conventional Warburg manometric techniques. Twice washed cell suspensions were found to have a high endogenous respiration rate, which could be effectively reduced by shaking the suspensions in phosphate buffer (pH 7) at 28° overnight. This preincubation, while markedly reducing the blank, had no effect on the utilization of subsequently added substrates. The final volume in each vessel was 2.5 ml, consisting of 1.0 ml cell suspension, 1.1 ml 0.05 M phosphate buffer (pH 7.0), 0.2 ml substrate (0.23 g/ml), and 0.2 ml 20% KOH in the center well which contained a piece of fluted filter paper. The substrate and KOH were introduced the next day just before the experiment. The substrates were tipped in from the side arm after an equilibration period. When mixtures of two sugars were studied, varying proportions of these were added to give a final concentration of 0.23 g/ml of substrate solution. In each experiment duplicate flasks of every substrate or mixture of substrates were observed. All experiments were repeated one or more times.

The nature of the high endogenous respiration was studied by determining the respiratory quotient (R.Q.), according to the methods of Umbreit, Burris, and Stauffer (**1957**).

Growth studies. In these studies minor modifications were made in the basal medium described above. A sterile 0.07 M glucose solution was prepared separately by Seitz filtration and diluted 1 to 25 with sterile basal salts medium which had been previously prepared.

A more uniform inoculum was obtained by seeding this medium from a slant and incubating on a shaker for 24 hours at room temperatures. After incubation the contents of each flask were dispensed in 5 ml quantities and shell frozen. For all the growth studies 0.25 ml of the thawed suspensions served as inocula.

Fifteen flasks were prepared for each substrate in the manner described above for glucose. After inoculation the cultures were shaken in a water bath at 28° C. At 24-hour intervals 3 flasks were harvested and the dry weights determined either by filtering through tared millipore filters or by centrifuging in tared tubes. The latter method was

used to avoid clogging of the filters by very dense cultures. In both methods the residual nutrients were removed by carefully washing with distilled water several times prior to drying to constant weight at 90–95° C.

Essentially the same procedure was used in the experiments with mixtures of sugars. Varying proportions of the constituent sugars were added to give a final total substrate concentration of 2% (w/v) in each flask.

RESULTS AND DISCUSSION

In FIG. 1 the studies on oxygen uptake of *N. rubra* in the presence of glucose, fructose, and sucrose are summarized. All values have been

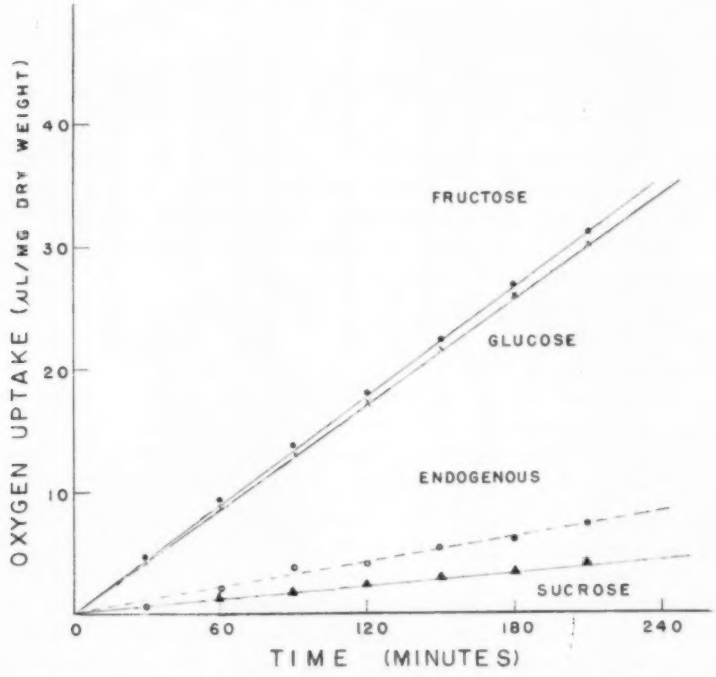

FIG. 1. Oxidation of fructose, glucose, and sucrose by washed suspensions of *Nocardia rubra* (7-day old), preincubated by shaking overnight in buffer. All values have been corrected for the residual endogenous respiration. Each Warburg vessel contained 1.0 ml cell suspension, 1.1 ml 0.05 M phosphate buffer (pH 7.0), 0.2 ml substrate (0.23 g/ml in all except the endogenous where buffer was added), and 0.2 ml 20% KOH in the center well to give a total volume of 2.5 ml. Water bath temperature 28° C.

TABLE I

UTILIZATION OF VARIOUS SUGARS BY NOCARDIA RUBRA*

Carbon source	Oxygen uptake μL O_2/mg dry wt/hr
A L(+)-Rhamnose	0.102
D(+)-Cellobiose	0.137
D(−)-Arabinose	0.153
Lactose	0.169
Sorbose	0.201
Maltose	0.276
B D-Galactose	0.975
Sucrose	1.128
D-Mannose	1.326
C D-Glucose	8.906
Fructose	8.962

* A twice washed suspension (1 ml) of *N. rubra* (from a 7-day old culture) was shaken overnight at 28° C with 1.1 ml 0.05 M phosphate buffer, pH 7.0. Next day, substrates and KOH were added to give final volumes of 2.5 ml. Substrates were tipped in from the side arms after a 30 minute equilibration. The oxygen uptake was followed for 2 hours. All values corrected for endogenous respiration.

corrected for endogenous respiration. The latter (broken line curve in FIG. 1) has been reduced to about 8% that of twice washed cell suspensions by shaking overnight in buffer. This reduction allowed detection of the utilization of poorly metabolized carbon sources which would otherwise be partially, if not completely masked. A similar high endogenous value was observed in *N. opaca* by Webley and de Kock (**1952**). The R. Q. of this endogenous respiration was 0.903, indicating that cellular proteins were probably being metabolized.

In the present study the utilization of eleven different sugars was determined. The results are shown in TABLE I. On the basis of oxygen uptake, these sugars may be placed into three groups; namely, *A*. L(+)-rhamnose, D(+)-cellobiose, D(−)-arabinose, lactose, sorbose, maltose; *B*. D-galactose, sucrose, D-mannose; and *C*. D-glucose, fructose. The sugars in groups *A* and *B* are utilized to about 1–3% and 11–15%, respectively, when compared with either sugar in group *C*. It appears from these results that pentoses and disaccharides are relatively poor carbon sources. The limited utilization of sucrose (also shown in FIG. 1) suggests that *N. rubra* is deficient in invertase since both hexoses (glucose and fructose) arising from it are very efficiently metabolized, i.e., about 8 times as well as sucrose. The overall pattern of utilization confirmed earlier qualitative growth studies (McClung, **1954a**).

Since specific mixed carbon sources have been reported to increase growth of various fungi (Horr, **1936**; Steinberg, **1939**), the effect of

a good carbon source such as glucose on the utilization of some of the other sugars was studied. Instead of following the growth rate over a long time interval, oxygen uptake in the presence of mixtures of sugars was used as an index of metabolism. Increased growth would be reflected in a stimulation of the respiration of poorer carbon sources.

Six of the less readily utilized sugars from groups *A* and *B* in TABLE I were tested with varying proportions of glucose. These results are shown in FIGS. 2, 3, and 4. The most pronounced stimulations were

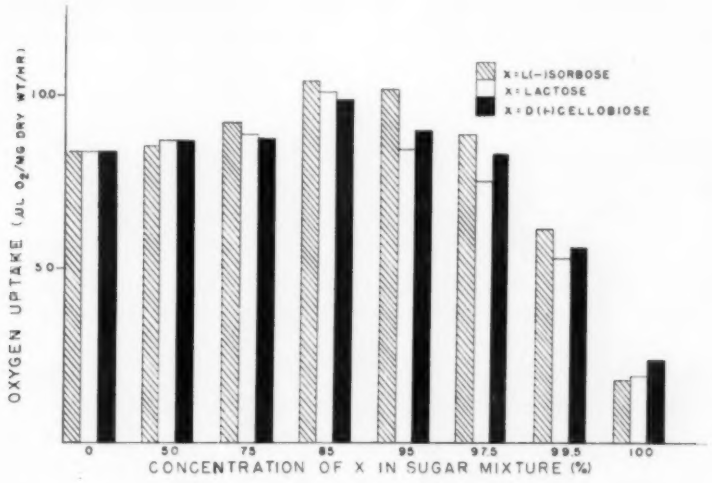

FIG. 2. Oxidation of sorbose-glucose, lactose-glucose, and cellobiose-glucose mixtures by *N. rubra*. Washed suspensions of 4-day old cultures were preincubated by shaking overnight in phosphate buffer (pH 7.0). Each vessel contained 1.0 ml cell suspension, 1.1 ml 0.05 M phosphate buffer, 0.2 ml substrate (0.23 g/ml), and 0.2 ml 20% KOH in the center well. All the values given have been corrected for endogenous respiration which was determined by adding 0.2 ml buffer instead of substrate. Water bath temperature 28° C.

observed in sorbose-glucose, lactose-glucose, and cellobiose-glucose mixtures containing 15% glucose and 85% test sugar (FIG. 2). The oxygen uptake in the first two mixtures was about 6 times greater than when only sorbose or lactose was present. In cellobiose-glucose mixtures, it was only about 4 times that of cellobiose alone. In all these experiments, the oxygen uptake with 85% test sugar and 15% glucose was higher than that in glucose alone suggesting that the increase observed cannot be attributed solely to the additional utilization of the

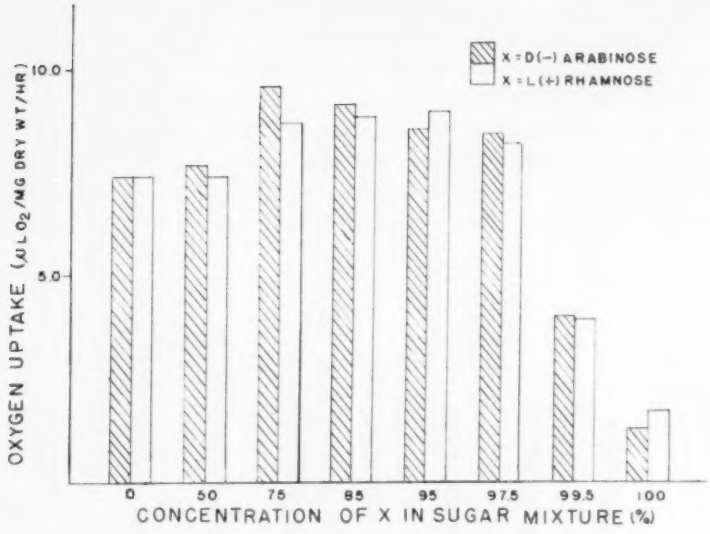

FIG. 3. Oxidation of arabinose-glucose and rhamnose-glucose mixtures by *N. rubra*. The experimental conditions were the same as described in Fig. 2.

small amount of glucose present in the mixture. There was a definite stimulation in the utilization of sorbose, lactose, and cellobiose.

In arabinose-glucose and rhamnose-glucose mixtures containing 15% glucose and 85% test sugar, the oxygen uptake was about 7 and 5 times, respectively, that of the pentose (FIG. 3). However, the synergistic effect of glucose at this concentration was not as well defined as in the three mixtures discussed above. Pure galactose seemed to be utilized almost as efficiently as glucose by the cell suspensions from 4-day old cultures used in the experiments on sugar mixtures. The results obtained with galactose-glucose mixtures are shown in FIG. 4. Even though no pronounced stimulation of galactose utilization was obtained under these experimental conditions, there was a definite increase in oxygen uptake when mixtures were tested. The presence of as little as 0.5% glucose resulted in an uptake 2–4 times that obtained for all the sugars studied except galactose. The negligible effect on the latter may be attributed to the fact that it is a good carbon source in itself.

The overall pattern of carbon utilization by cell suspensions from 4-day old cultures differed considerably from that of 7-day old cultures. In TABLE II the oxygen uptake of these two age groups is compared.

The behaviour with glucose was essentially the same, but arabinose and galactose were utilized 8 times more efficiently by the younger cells. The difference in metabolic activities was even more pronounced with lactose (11.5 times), rhamnose (17 times), and cellobiose (18 times). These results emphasize that cultures in the same stage of metabolic activity should be used if a quantitative evaluation of the carbon metabolism of various species of *Nocardia* is to be obtained.

In preparing cells for the foregoing respiration studies, there was considerable variation 1) in the yield of cells harvested from different flasks inoculated at the same time with equal amounts of a seemingly uniform suspension; 2) in the oxygen uptake/mg dry weight in replicate trials with suspensions from different flasks containing cultures of presumably the same age; and 3) in the oxygen uptake/mg dry weight in experiments carried out with cultures of the same age but grown at different times. These variations were probably due to irregular frag-

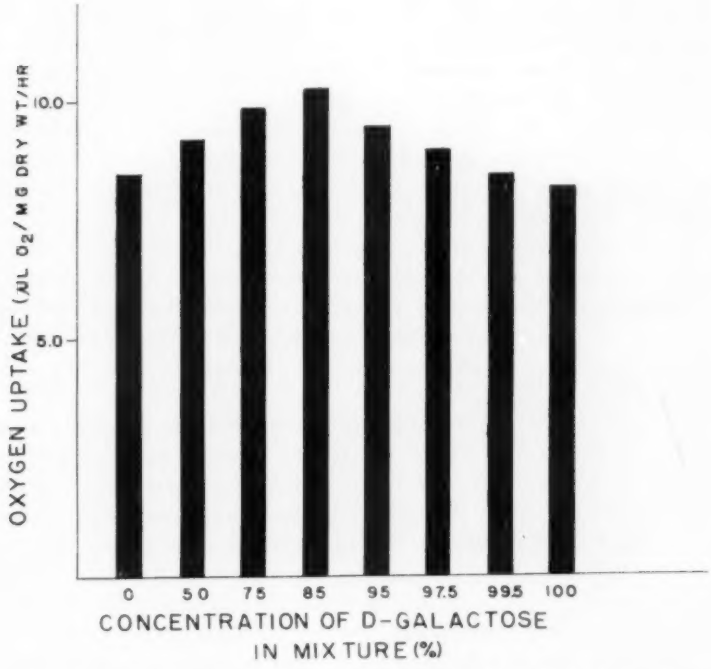

FIG. 4. Oxidation of galactose-glucose mixtures by *N. rubra*. The experimental conditions were the same as described in Fig. 2.

TABLE II

EFFECT OF AGE OF CULTURE ON OXYGEN UPTAKE OF NOCARDIA RUBRA

Carbon source	Oxygen uptake μL O_2/mg dry wt/hr		B/A
	A* 7-day old	B** 4-day old	
L(+)-Rhamnose	0.102	1.744	17.1
D(+)-Cellobiose	0.137	2.404	17.9
D(−)-Arabinose	0.153	1.298	8.5
Lactose	0.169	1.949	11.5
D-Galactose	0.975	8.060	8.3
D-Glucose	8.906	8.459	0.95

* Values taken from TABLE I.

** Values taken from FIGS. 2, 3, AND 4 where the incubation mixture contained a single carbon source.

mentation of mycelium resulting in cells of different ages within a single culture—the proportion of the various stages being completely random (McClung, **1954b**). In all the preceding experiments, the cell suspensions used were obtained by pooling all the flasks cultured at one time. The values obtained for replicates from such a pooled batch agreed within the range of experimental error. The same general trends and stimulatory effects of glucose were observed in the behaviour of *N. rubra* of the same age toward the various sugars even though the range of values for the oxygen uptake/mg dry wt/hr cannot be rigidly defined for any substrate or pair of substrates.

The aforementioned variations were reduced by culturing in smaller volumes of medium and by producing more uniform inocula. The former reduced the tendency of *N. rubra* to form clumps which were difficult to resuspend. The latter was achieved by using 0.25 ml of 24-hour shell-frozen stock suspensions as inocula as described under *Growth studies*.

The growth of *N. rubra* was studied with these modifications in the cultural conditions. In Fig. 5 the results obtained for several carbohydrates are presented. Growth was expressed in terms of dry weight. These results confirmed the qualitative observations of earlier growth studies (McClung, **1954a**) as well as the respiration studies described above. The results showing that the sugar alcohols, sorbitol and mannitol, were more readily utilized than the corresponding aldosugars need elucidation by future study.

Maximum growth was attained in three or four days for a number of the carbohydrates tested. This was followed by a pronounced drop in dry weight when mannitol or glycerol was the sole carbon source.

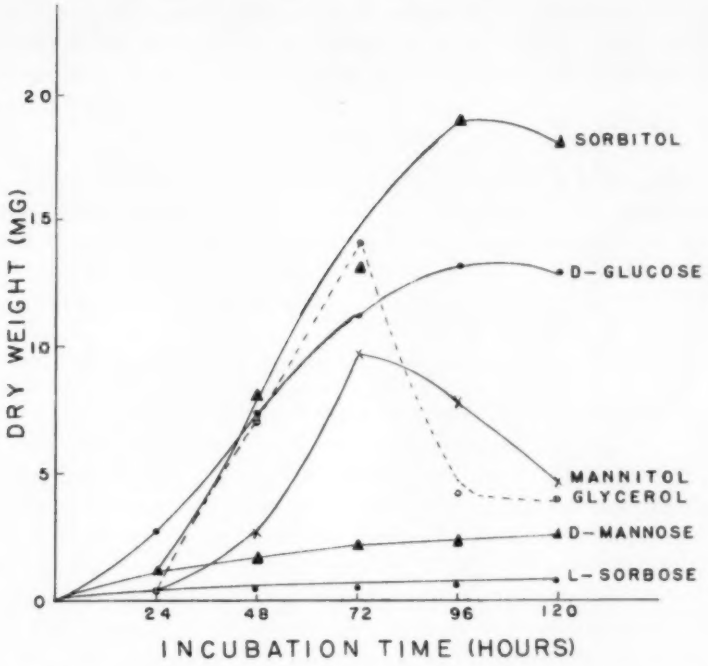

FIG. 5. Growth curves of *N. rubra* in the presence of glucose, sorbose, mannose, glycerol, sorbitol, and mannitol. Fifteen flasks were set up for each substrate. Each flask contained 2 ml 0.07 M substrate in a total volume of 50 ml. These were inoculated with 0.25 ml of previously frozen suspensions 24-hour cells and incubated with shaking in a water bath maintained at 28° C. Three flasks were harvested at 24-hour intervals and the dry weights determined.

With glucose and sorbitol, the growth cycle reached a stationary phase. These results supported the earlier observations of greater metabolic activity in cell suspensions from 4-day old cultures (cf. TABLE II).

In Fig. 6 the results obtained with four sugar mixtures are summarized. The proportions of the constituent sugars were the same as those in the respiration studies. The synergistic effect of glucose was evident in lactose-glucose, arabinose-glucose, and cellobiose-glucose mixtures. In rhamnose-glucose mixtures the effect was less pronounced. These results essentially confirmed those obtained in the respiration studies.

The stimulatory effect of glucose observed in both these studies may be attributed in part to the presence of a readily metabolizable carbon

source which enabled the organisms to overcome the lag encountered when a poorly utilized substrate was the sole carbon source. The exact nature of this effect awaits further investigation.

SUMMARY

Respiration studies of *N. rubra* confirmed earlier qualitative studies on carbohydrate utilization. The inherent high endogenous respiration of the cells was reduced to less than 10% by shaking overnight in phosphate buffer (pH 7). The pattern of utilization varied with the age of the cultures used, e.g., 4-day old being metabolically more active than 7-day old on a number of the sugars.

When one of the less readily utilized sugars was replaced in part by glucose, the oxygen uptake was considerably higher than with either sugar alone, showing that glucose stimulated the utilization of the other sugar. This effect was observed in mixtures containing 15–50% glucose.

Although the oxygen uptake/mg dry weight varied considerably with different batches of cells of the same age, the same general trends were observed within an age group. This variation may be due to the random mixtures of cells of different ages in the seemingly uniform inoculum used initially. This was overcome by using as inocula frozen stock suspensions of 24-hour shake cultures of *N. rubra* grown in a 0.07 M glucose medium.

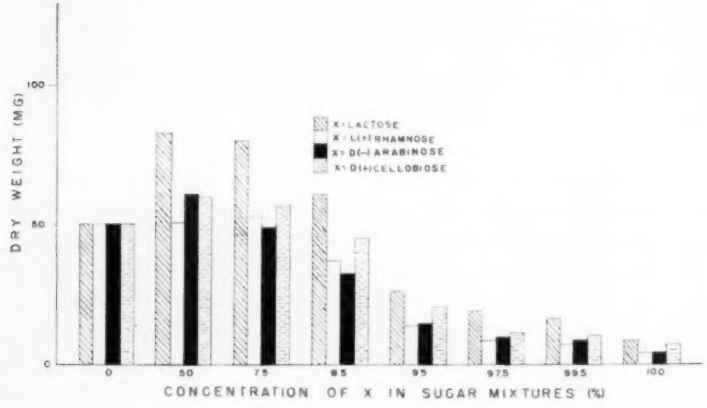

FIG. 6. Growth of *N. rubra* in the presence of various sugar mixtures. The experimental conditions were essentially those given in Fig. 5, except that substrates were added to give a final concentration of 2% (w/v). The dry weights were determined after a 24-hour incubation.

Such inocula were used in growth studies, in which the quantitative growth curves for several carbohydrates paralleled earlier growth studies. The patterns in mixtures of sugars confirmed the results from respiration studies.

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THE GENUS CYMATODERMA (THELEPHORACEAE) IN THE AMERICAS

A. L. Welden [1]

(with 5 figures)

In 1827 [2] Persoon described *Thelephora dendritica* in Gaudichaud's botanical account of the Uranie voyage. This report appears to be the first description of any species of *Cymatoderma*. Berkeley transferred *Thelephora dendritica* in 1842 to *Cladoderris*.[3] However, two years earlier Junghuhn had described the genus *Cymatoderma* based on *C. elegans* from Java. While the relationship between the two species has been recognized [see Lloyd (**11**) and one of his characteristic comments], the later name *Cladoderris* has been more widely used than the valid *Cymatoderma*. This has necessitated a large number of transfers and has contributed little to nomenclatorial stability.

Tropical and subtropical stereoid fungi have been assembled into a few large genera composed of many heterogeneous elements. Possibly one of the major contributory factors to such groupings has been the reliance upon macroscopic characters. Such characters are often misleading and their exclusive use has resulted not only in discordant genera, but in the recognition of many "new" species which are only growth forms. A study of microscopic anatomy, as well as external morphology, enables the investigator to draw more natural lines of relationships. Among others Cooke (**4**), Corner (**5**), Eriksson (**8**, **9**), Pinto-Lopes (**12**), Rogers (**14**, **15**) and Singer (**16**) have shown the value of such characters. In the stereoid fungi Boidin (**1**, **2**), Lentz

[1] The earlier portion of this work was begun in 1952–53 as a field assistant to Prof. G. W. Martin. The Tulane Graduate Council on Research has supported trips to important U. S. herbaria for study, and the American Philosophical Society made possible a field trip to Jamaica in 1957. The later portion of this study has been supported by a grant from the National Science Foundation.

[2] Sherborn and Woodward (Jour. Bot. **39**: 206. 1901) give the date of issue of Livr. 5 (6 sheets) of Gaudichaud's *Voyage* II. 169–216 as 1827. Their dates are copied from the Ann. Mag. Nat. Hist., April 1901 whose authority is Férussac **13**: 75. 1828.

[3] For a discussion of the nomenclature and the attempt to conserve *Cladoderris* see Donk, M. A., Bull. Bot. Gard. Buitenzorg III **17**: 155. 1941, and Rogers, D. P., Farlowia **3**: 436. 1949.

(**10**), Reid (**13**), and Talbot (**17**, **18**) have been using microscopic characters to dissect *Stereum* and its relatives into more natural units. A study of tropical stereoid fungi is fraught with difficulties, especially a genus such as *Cymatoderma*. While most of the species have been described as *Cladoderris*, there is no assurance that all Cladoderri are in *Cymatoderma*. Some are not. Any name for a tropical stereoid fungus may conceal a *Cymatoderma*. Several important type collections were destroyed during the last World War, a particularly frustrating situation. Untangling the extensive synonymy is a Sisyphean task. However, these and other difficulties are the familiar traveling companions of the mycologist interested in the tropics. Most of these handicaps in a study of *Cymatoderma* have been surmounted by the careful and painstaking work of recent investigators, and their refusal to treat the genus in a Lloydian manner has made the present work all the easier.

The closest relatives of *Cymatoderma* are *Stereum* sensu stricto and *Podoscypha*. *Lopharia cinerascens* (Schw.) Cunningh. may be another close relative. Later, there may be some merit in treating *Podoscypha* as a section of *Cymatoderma;* certain Asiatic species in both genera seem to overlap in some of their characters. The validity of this suggestion, however, must await a detailed study of Asiatic Cymatodermas and a revision of *Podoscypha*, a massive task of synonymy as well as anatomy. Any further discussion of the relationships of *Cymatoderma* now would be premature.

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Beccariella Ces., Atti Acc. Sci. Fis. Mat. Napoli **8** (repr.): 9. 1879 (pro parte).

TYPE species: *Cymatoderma elegans* Jungh.

Basidiocarp lignicolous, saprobic, separate to densely caespitose, spathulate through flabelliform, pseudoinfundibuliform to infundibuliform, papery-coriaceous, coriaceous, spongy-coriaceous, sessile, rarely approaching effuso-reflexed, substipitate to stipitate, arising from a

mycelial pad or sclerotium, creamy-white to dark reddish brown or purple-fuscous (the darker colors often present in older specimens); *pileus* azonate to zonate, covered with a well-developed tomentum which may be reduced to simple or branched spines, faintly lineate-striate, smooth or thrown into folds or knifelike ridges, the tomentum or spines abundantly developed toward the base; *hymenial surface* smooth, wavy, or with shallow or deep folds which tend to branch and become more numerous toward the margin, scattered to dense, blunt or acute papilla may be present.

In section pileus of three zones: the cuticle and its tomentum, the context, and the hymenium; tomentum of hyaline or brownish yellow hyphae with thickened to solid walls, with or without clamp-connections; cuticle of tightly interwoven or more or less longitudinally parallel, pigmented hyphae; context closely interwoven, hyaline to brownish yellow, hyphae hyaline or pigmented, thin-walled with clamp-connections, or thickened to subsolid and solid, with or without clamp-connections and with or without branches, certain subsolid to solid hyphae twist and turn, certain others are short and branched, and others tend to be straight and unbranched.

Hymenium of basidia, basidioles, gloeocystidia, and, in one species, dendrophysoid structures; gloeocystidia clavate, cylindrical, ventricose-cylindrical to ventricose-moniliform, arising below or within the context and extending into, but rarely beyond, the hymenium; basidia and basidioles cylindrical-clavate; sterigmata straight, or slightly curved, tapering to acute points; basidiospores subglobose to subcylindrical, hyaline, smooth, nonamyloid; hymenium thickening with age.

KEY TO THE AMERICAN SPECIES OF CYMATODERMA

a. Basidiocarp infundibuliform, upper surface tomentose, especially toward the base; spores 7–11 × 3–5 μ.....*C. caperatum*
a. If the basidiocarp is infundibuliform then the tomentum is replaced by spines and spores smaller.....b
b. Pseudoinfundibuliform; stipes relatively long, covered by a brown, velvety tomentum, and arising from a sclerotium.....*C. sclerotioides*
b. If basidiocarp is pseudoinfundibuliform then the stipe is not long and covered with a brown, velvety tomentum, arising from a mycelial pad rather than a sclerotium.....c
c. Hymenial surface of the basidiocarp densely covered with numerous papillae; cinnamon or darker when dry.....*C. fuscum*
c. Hymenial surface devoid of papillae or papillae scattered and few in number; rarely as dark as cinnamon when dry.....d
d. Upper surface of pileus densely tomentose; hymenial surface covered with many, branching, radiating and more or less acute folds..*C. dendriticum*
d. Upper surface of pileus bearing simple or branched spines rather than a tomentum; hymenial surface smooth or with only a few broad, shallow folds.....*C. cristatum*

THE MACROSCOPIC GENERIC CHARACTERS

Basidiocarps, Habit, and Habitats. All American species of *Cymatoderma* are saprobic and wood-inhabiting. I have never collected them growing upon standing trees but only on fallen monocotyledonous and dicotyledonous plants. The monocotyledons have all been palms. While none of the species are resupinate, *C. dendriticum* does approach the effuso-reflexed condition on occasion. The basidiocarps are sessile, substipitate, or stipitate. The extent of stipe development is a function of the relationship of the fruiting primordium to the substrate rather

FIG. 1. *Cymatoderma caperatum* (Berk. et Mont.) Reid. Slightly reduced.

than an innate character of the fungus. It would be best to exclude *C. sclerotioides* and *C. cristatum* from this discussion of stipe development since only two and three limited collections, respectively, are known of these fungi. In *C. fuscum* a stipe develops when the basidiocarp initial is below the soil surface or toward the lower surface of the substrate. The same pattern exists in *C. caperatum,* although I have never seen it growing from buried wood. If *C. dendriticum,* which typically has several pilei emerging from a common pad, has the pad positioned toward the lower surface, it will grow outward and upward forming a pseudostipe. As a generalization, only enough stipe forms

to properly orient the hymenial surface for spore discharge, i.e., more or less parallel with the earth's surface. Such hymenial organization, as Corner (7) has pointed out, protects the developing basidia from rain damage, an important consideration under humid tropical conditions.

The size and shape of the basidiocarps are also variable characters. Size varies in the extreme in each species. Some sporocarps are massive, others very small, and both extremes may be present in the same collection. Obviously size cannot be considered of taxonomic import. Infundibuliform fruit-bodies are characteristic of *C. caperatum* and *C. cristatum,* although in *C. caperatum* the development of one side may be slower giving the species a pseudoinfundibuliform appearance. The other species vary from spathulate through pseudoinfundibuliform. If the pilei are close together when they form, their margins may fuse, sometimes quite intimately, and they become pseudoinfundibuliform when mature. *Cymatoderma sclerotioides* and *C. fuscum* are much more likely to be pseudoinfundibuliform than *C. dendriticum.* The stipes of *C. sclerotioides* become fused, and the one or more pilei arising from such a stipe may fuse to one another along their margins.

Mycelial Pads. The basal mycelial pads are characteristic of both *Cymatoderma* and *Podoscypha.* When these pads are sectioned longitudinally, one or more central "cores" of lighter colored tissue (FIG. 3C) are observed. These "cores" may be either one to several in number, independent and unbranched or they may be with or without branches. If the fruit-body is stipitate, the branches of the "cores" may not be evident except at the stipe apex. In *C. caperatum* they are typically independent of one another even when more than one pileus arises from the same pad. *Cymatoderma cristatum* tends to be similar. In *C. dendriticum* the "core" may be branched, and in *C. fuscum* it may be branched or unbranched. This character is difficult to determine in *C. sclerotioides* since the prominent stipe arises from a sclerotium, but the "core" does branch at the apex of the stipe. Thus far I have been unable to clearly determine if the "cores" arise within the pads, or if the pads are outgrowths or overgrowths of the "cores." The issue is further complicated when the basal pad is continuous with the tomentum, as it often is in *C. dendriticum.*

Texture. Sporocarp texture is somewhat more constant. It varies from papery-coriaceous in *C. cristatum* to spongy-coriaceous in *C. dendriticum* and *C. fuscum.* Texture is an indirect measure, albeit a rather subjective one, of hyphal development. The leathery texture is deter-

mined by the thickened hyphae of the context; the spongy texture is dependent on the extent of the tomentum. *Cymatoderma cristatum* has a relatively thin context and no tomentum. While *C. dendriticum* also has a thin context, it does have a profuse tomental development. In one collection of *C. caperatum* there is no tomentum and a thin context gives an overall papery-coriaceous texture. In other collections of this species the tomentum and context are thick but the margin is thin, therefore, the margin is papery-coriaceous to coriaceous and the pileus spongy-coriaceous toward the base. *Cymatoderma sclerotioides* is similar. The collections of *C. fuscum* are all spongy-coriaceous and all have a well-developed tomentum.

Upper Pileus Surface. Most often the nature of the pileus surface is hidden by the tomentum. In *C. cristatum,* where the tomentum is reduced to spines, the upper surface is smooth, faintly radiate-striate, and narrowly multizonate with alternating light and dark bands. The upper surfaces of *C. caperatum* and *C. sclerotioides* are thrown into knifelike folds. Similar folds in *C. dendriticum* and *C. fuscum* are not so well-developed and are obscured by the tomentum.

Papillae. While papillae may occur on the hymenial surface of most species of *Cymatoderma,* the extent of their development in each species is significant. Papillae are completely absent in *C. cristatum,* rare and scattered in *C. dendriticum, C. sclerotioides,* and *C. caperatum,* but regular and extensive in *C. fuscum,* which is the only regularly papillate American species. The papillae of *C. fuscum* are formed by clusters of incrusted hyphae and crystals immediately below or within the hymenium. The hymenium may be interrupted by the papillae or it may form over the papillae. The crystals dissolve in an alkaline solution.

Hymenial Surface. Excepting possibly *C. cristatum,* all species of *Cymatoderma* possess a rugose hymenium. Generally there are several major folds toward the base, especially in *C. caperatum* and *C. sclerotioides,* which branch toward the margins. The folds are more numerous and acute in *C. dendriticum.* The papillae obscure the folds in *C. fuscum,* except toward the margins where the papillae are scattered. These folds do not approach the acuteness of *Cantharellus* or the delicacy of *Craterellus.* The hyphae, texture, and other characters preclude any confusion of *Cymatoderma* with these genera.

Basidiocarp Color. The basidiocarp color is not a reliable character. The fresher and younger the fruit-body the lighter the color. Creamy

white to buff or beige obtain in the fresh collections of *C. caperatum* and *C. dendriticum,* but these species become darker with age and take on reddish brown or purplish tints. Indeed, the tomentum of *C. dendriticum* sometimes becomes purple-fuscous with age. Sporocarps of *C. cristatum* have not been observed in the field, but the colors of her-

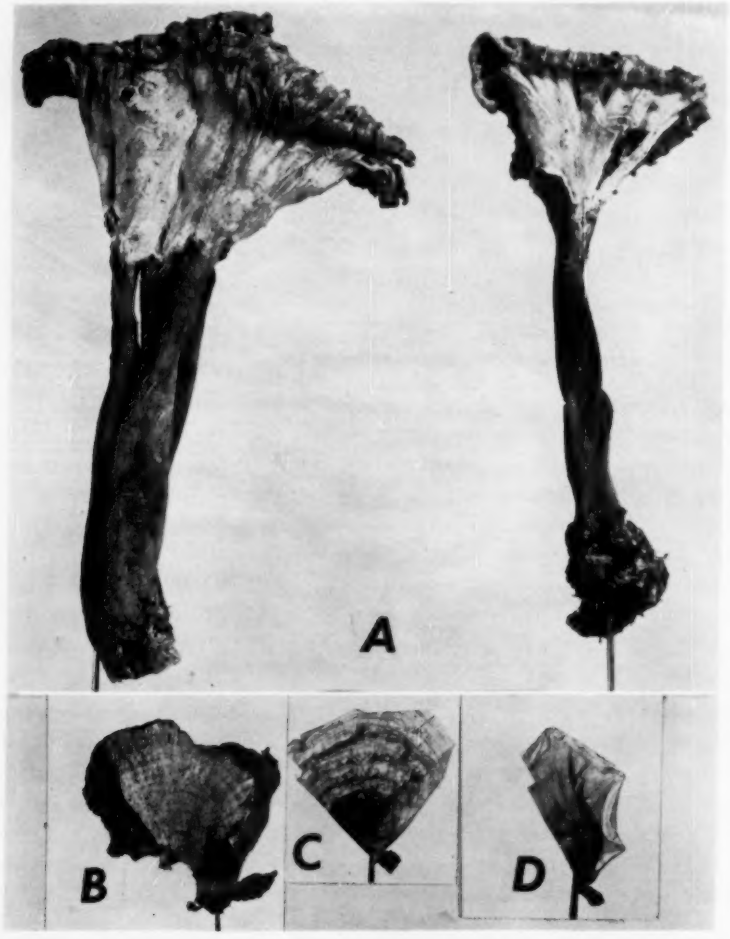

FIG. 2. A. *Cymatoderma sclerotioides* (Lloyd) Reid., × 1. B. *Cymatoderma fuscum* (Cke.) Reid., ×1. Sessile form. C, D. *Cymatoderma cristatum* (Berk. et Curt.) Welden. C. Upper surface of the pileus showing spines. D. Lower surface of the pileus.

barium specimens indicate tones similar to those of *C. caperatum*. The few specimens of *C. sclerotioides* indicate little color change, while *C. fuscum* darkens appreciably with age.

THE MICROSCOPIC GENERIC CHARACTERS

In hand sections made along the long axis of the pileus three zones or regions can be observed: the cuticle and tomentum, the context, and the hymenium, including the subhymenium.

Tomentum and Cuticle. Only in *C. fuscum* are the majority of tomental hyphae pigmented. Some pigmented hyphae may occur among the tomental hyphae in the other species, but the majority are hyaline. The pigment is brownish yellow and may be light or dark in tone. The morphology of the hyphae varies from those whose walls are only thickened with conspicuous clamp-connections, as in *C. dendriticum*, to those which are solid to subsolid and with rare clamp-connections. These latter types are characteristic of *C. fuscum*. The remaining species, *C. caperatum*, *C. cristatum*, and *C. sclerotioides*, have both thick-walled and solid hyphae in their tomentum.

A deeply pigmented and tightly interwoven cuticle is present in *C. sclerotioides* and *C. fuscum*. It is more or less interwoven in *C. caperatum*, *C. cristatum*, and *C. dendriticum* but less so in *C. dendriticum* where it approaches the longitudinally parallel condition found in *Stereum* and *Podoscypha*. In some collections of *C. dendriticum* the cuticle is almost completely absent. Reid (**13**) reports the cuticle of *C. fuscum* as absent, but in my collections it appears quite distinct. Within the limits described above, the distinctness of the cuticle probably increases with the age of the basidiocarp.

Context. The context of all species of *Cymatoderma* is closely interwoven and more or less hyaline, except in *C. fuscum*. In that species the context is brownish yellow giving the flesh a fuscous or pale brown appearance. There are several types of hyphae present in the context: (1) long, rarely branched or clamped, subsolid to solid hyphae arising abruptly or gradually from thin-walled hyphae, (2) solid or subsolid hyphae similar to (1) but narrower, twisting and turning and found more abundantly toward the subhymenium, (3) solid or subsolid, narrow, short- or long-branching hyphae also found toward the subhymenium, and (4) thin-walled, relatively wide, branching and clamped hyphae throughout the context. Intermediates between these hyphae may also be found.

Hymenium and Subhymenium. Profusely branching, clamped, thin-walled hyphae compose the subhymenium. These hyphae are similar to the thin-walled contextual hyphae but have a narrower diameter, shorter cells and more abundant branching. The subhymenium may be so well-developed and so tightly interwoven in some collections as to appear as a granular layer beneath the hymenium. In other collections it is inconspicuous. The subhymenial hyphae give rise to the basidia and basidioles. Dendrophysoid structures are also found in some of the older portions of the hymenium of *C. caperatum.* The gloeocystidia arise from the subhymenium or from the context near the subhymenium, and may or may not completely traverse the hymenium and protrude slightly beyond it. Thus, they are often found at all levels in the hymenium. When young the gloeocystidia are broadly clavate-cylindrical, but at maturity they are ventricose-cylindrical to ventricose-moniliform in shape. They remain thin-walled and are, therefore, capable of indefinite growth. The submoniliform and moniliform appearance of their distal ends seems to indicate that their growth is not continuous but occurs at intervals. Since it appears that the gloeocystidia are of indeterminate growth, their measurements cannot be diagnostic.

Basidia and basidioles are cylindrical-clavate and their length is determined by their point of origin within the hymenium. The only noteworthy variation occurs within *C. caperatum* where the basidia and basidioles are larger than in the other species. The sterigmata of all species are straight or slightly curved and taper to acute points.

The spores range from subglobose to subcylindrical and are hyaline, smooth, and nonamyloid. The largest spores are produced by *C. caperatum.* The apiculi of all spores are inconspicuous.

Hyphal Terminology. Reid (**13**) has divided this genus into two sections: *Cymatoderma* which is dimitic in hyphal structure, and *Cladoderris* which is trimitic. I am not certain as to how Corner's (**6**) terms should be applied in connection with this genus. Each of the hyphal types discussed above can be found in all of the American species. Certainly the thin-walled, clamped, and branching hyphae (FIG. 5O) can be termed generative hyphae, and the long, rarely branched, solid to subsolid hyphae without clamps (FIG. 5L) may be termed skeletal hyphae. But what of the solid, rarely branched, clamped hyphae, and the solid twisting and turning hyphae? Surely the former cannot be called "generative," for they obviously function in support and are skeletal. The latter types are not wholly skeletal because they do aid in binding. Those solid to subsolid hyphae which branch sev-

eral times fit the descriptions of binding hyphae. I do not wish to negate the useful terms "dimitic" and "trimitic," but a strict interpretation of Corner's terms does not appear applicable in the American species of *Cymatoderma* unless all of the species are considered trimitic.

The function of a hypha is determined to some extent at least by the rate at which its walls thicken. Some of the hyphae turn into the hymenium and rapidly form the thin-walled hymenial structures such as basidia, basidioles, and gloeocystidia. These hyphae rarely, if ever, thicken in *Cymatoderma*. In other genera they do thicken. In *Xylobolus* Karst. emend. Boidin, e.g., the basidioles form the acanthophyses characteristic of that genus. Other hyphae in *Cymatoderma* remain thin-walled and clamped but may slowly thicken until the entire lumen is obliterated. If the thickening occurs rapidly, clamp formation and branching will be inhibited and the hyphae will be typical skeletals. Often the apices of these solid hyphae remain thin-walled and are potentially capable of unlimited growth. Some hyphae branch rapidly several times and thicken quickly; these are the binding hyphae. Undoubtedly culture work along lines similar to that of Pinto-Lopes (**12**) will help explain these hyphal types in *Cymatoderma*.

CYMATODERMA CAPERATUM (Berk. et Mont.) Reid, Kew Bull. **1955**: 635. 1956; *Thelephora caperata* Berk. et Mont., Ann. Sci. Nat. Bot. III. **2**: 241. 1849; *Stereum caperatum* (Berk. et Mont.) Massee, Jour. Linn. Soc. Bot. **27**: 161. 1890 (non *S. caperatum* Lloyd which is *S. cinerascens* (Schw.) Massee, sec. Talbot, Bothalia **6**: 308. 1954); *Cladoderris caperata* (Berk. et Mont.) Pat., Essai Tax. 73. 1900. FIGS. 1, 4A–D

Stereum hylocrater Speg., Ann. Soc. Ci. Argent. **17**: 77. 1884.
Stereum goliath Speg., Ann. Soc. Ci. Argent. **17**: 77. 1884.

Basidiocarp spongy-coriaceous, rarely papery-coriaceous, creamy white to reddish brown, often with vinaceous tints, sessile to stipitate, separate to caespitose with fused pilei, infundibuliform, 2–14 cm high, 2–12 cm wide; *upper surface* with many radiately folded ridges covered with projecting hyphae varying from loose tufts toward the margin to a more or less well-developed tomentum toward the base; *hymenial surface* wavy to radiately rugose, the folds branching toward the margin; *stipe*, when present, smooth, concolorous with the hymenial surface or covered toward the base with a brownish tomentum, arising from a well-developed mycelial pad.

Tomental hyphae 4–6 μ in diam, solid, or thickened and clamped, branching or not, hyaline or lightly pigmented; cuticular layer inter-

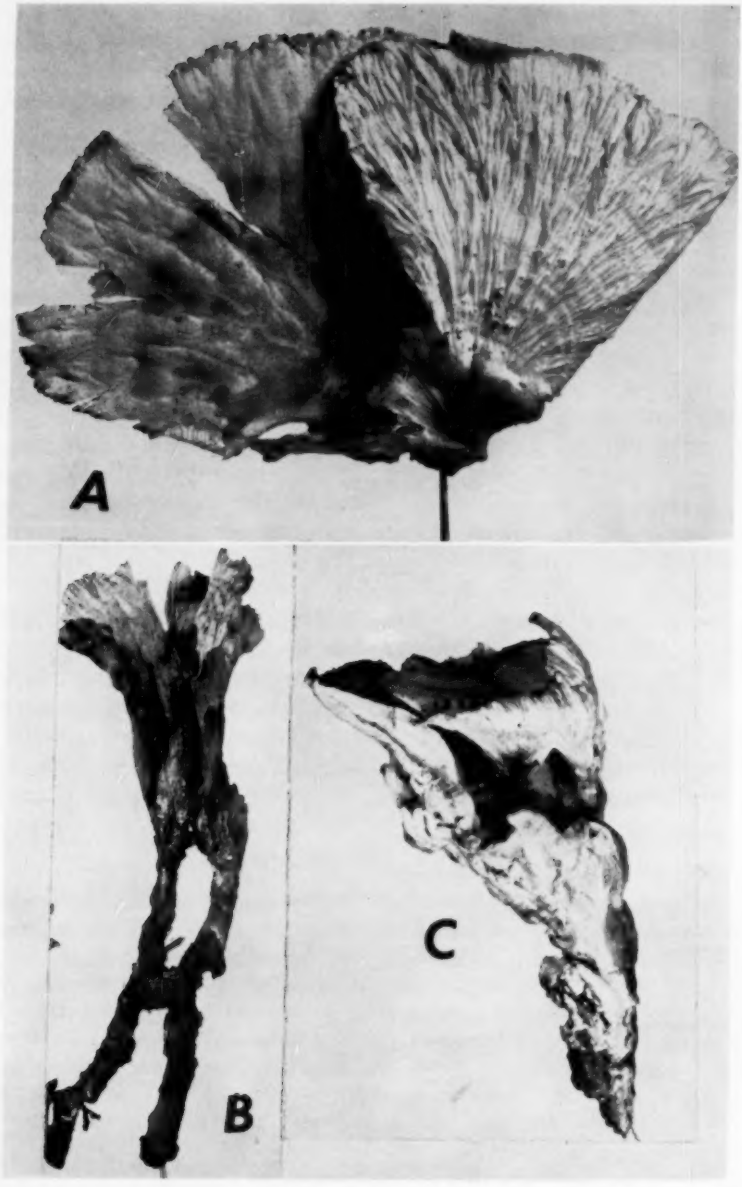

FIG. 3, A–C.

woven but not so much as in some other species, hyphae are long and sometimes branched; contextual hyphae of narrow solid hyphae distributed mostly toward the subhymenium 2–3 μ in diam, solid to subsolid unbranched hyphae 4–5 μ in diam, solid to subsolid branching hyphae 2–3 μ in diam, thin-walled hyphae 3–4 μ in diam.

Hymenium with characteristic gloeocystidia, 65–231 × 10–17 μ; numerous branching and tapering basidioles resembling dendrophysoid structures present, 3–5 μ in diam; basidia (25–)40–60(–72) × 6–12 μ, with 4 straight or slightly curved sterigmata; spores subcylindrical (7–)10–11 × 5–6 μ.

Habitat: Dead wood.

Distribution: Warm temperate and tropical America.

Specimens examined: Paraguay: as *Stereum goliath* Speg. (NO); Bolivia: *Britton & Rusby dist. 295* (NY), *Bang 295* (NO); Venezuela: *Maguire, Cowan & Wurdack 30346* (NY); Panamá: *Martin & Welden 7270* (NO); St. Kitts: *Britton & Cowell 672* (NY); Jamaica: F 1867 (NO), *Britton & Marble 338* (NY); Cuba: *Earle & Murrill 180* (NY), *Taylor 348* (NY), *C. Wright 400* (NY); Florida: *Cain,* Sept. 1954 (NO), *Long 12373* (NY), *Murrill,* June 1938 (NY), *West,* July 1931 (NY); Georgia; *Campbell* USDA—FP9962F (NY), *Harper 1923a* (NY); Louisiana: *Langlois 2492* (NY), *Welden 75, 77,* Parishes of St. Charles, St. Martin, St. Tammany, W. Feliciana, and Iberia, (NO).

Cymatoderma caperatum is somewhat anomalous. The presence of dendrophysoid hymenial structures, relatively large basidia and spores, and the constantly infundibuliform sporocarps are distinctive. The only closely related species outside the genus is *Lopharia cinerascens* (Schw.) Cunningh. Perhaps, both species have aleurodiscoid affinities as well as stereoid ones.

CYMATODERMA CRISTATUM (Berk. et Curt.) comb. nov.; *Stereum cristatum* Berk. et Curt., Grevillea 1: 163. 1873. FIGS. 2C, 5G–L

Basidiocarp papery-coriaceous to coriaceous, separate to caespitose, near Cordova (7 J 11, Maerz & Paul, ed. 2) at base, fading to near cream (9 D 2) toward margin, infundibuliform, separate to caespitose, 1–3 cm tall, 1–4 cm wide; *upper surface* faintly radiate-striate, base color cream buff, darker toward the base, multizonate with many narrow and wide zones of alternating light and dark colors, tomental hyphae

FIG. 3. A. *Cymatoderma dendriticum* (Pers.) Reid. B. *Cymatoderma fuscum* (Cke.) Reid. Stipitate form. C. *Cymatoderma dendriticum* (Pers.) Reid. Section through a sporocarp showing the central "core." All × 1.

organized into simple or branched spines, concolorous with the pileus, scattered to absent toward the margin; *hymenial surface* smooth with only a few inconspicuously shallow folds which may be caused by drying; *stipe* short, tomentose with a dark brown, compressed tomentum, arising from a buff brown mycelial pad.

Cuticle of more or less longitudinally parallel hyaline or lightly pigmented hyphae, thin-walled with clamps and solid to subsolid without clamps; context with solid to subsolid hyphae infrequently branched or clamped, 4(–6) μ diam which arise from thickened, branching, clamped hyphae which often have many secondary septa, ca. 4 μ diam, other solid to subsolid twisting and turning hyphae 2 μ diam with long or short spur- or prong-like branches, no clamps. Gloeocystidia up to ca. 90 $\times$ 4–11 μ; basidia not observed; basidioles 16–23 $\times$ 3–4 μ; spores (only ten seen) 4(–5) $\times$ 2–3 μ.

Habitat: Dead wood.

Distribution: Venezuela and South Carolina.

Specimens examined: Venezuela: Estado Bolivar, *Cardona 727* (IA); South Carolina: Herb. G. Massee (NY), Santee Canal, *Ravenel 760* TYPE (FH).

The basidiocarp shape has been rather difficult to interpret. All of the fruit-bodies I have seen have been pressed in drying and the type is glued to its sheet, but from all appearances they are infundibuliform. The Massee collection at The New York Botanical Garden may be a portion of the type. The major part of the description given here has been taken from the Venezuelan collection because it is in better condition than the others. *Cymatoderma cristatum* is the most *Stereum*-like species of the genus. However, the internal organization and morphology of the hyphae make it impossible to retain it within *Stereum*. Among the Cymatodermas this species is sharply characterized by the presence of spines rather than tomentum on its upper surface.

CYMATODERMA DENDRITICUM (Pers.) Reid, Kew Bull. **1958**: 523. 1959; *Thelephora dendritica* Pers., Gaud. Voy. Uranie Bot. 176. 1827; *Cladoderris dendritica* (Pers.) Berk., Hooker's London Jour. Bot. **1**: 152. 1842. FIGS. 3C, 5M–P

Thelephora crassa "Kunze Plantae Surinamense in Herbario Reichenbachiano"; *Actinostroma crassa* (Kunze) ex Klotzsch, in Meyen, Nova Acta Akad. Caes. Leop.-Car. Nat. Cur. **19** (suppl. 1): 237. 1843; *Cladoderris crassa* (Kl.) Fr., K. Vet. Akad, Handl. **1848**: 142. 1849 [non *Thelephora crassa* Lév. vel *Stereum crassum* (Lév.) Fr. which is *Hymenochaete crassa* (Lév.) Berk. et Curt.].

Cladoderris candolleana Lév., Ann. Sci. Nat. Bot. III. **5**: 153. 1846.
Beccariella trailii Cke., Grevillea **20**: 33. 1891; *Cladoderris trailii* (Cke.) Lloyd, Synop. Genus Cladoderris. Mycol. Writ. **4**: 5. 1913.
Cladoderris imbricata Pat., Bul. Soc. Mycol. France **38**: 86. 1922 (teste Reid).
Stereum fenixii Lloyd, Mycol. Writ. **7**: 1115. 1922 (teste Reid).

Basidiocarp spongy-coriaceous, separate to caespitose, pallid white through vinaceous or reddish brown to gray, spathulate to flabelliform, 1.5–10 cm tall, 2–14 cm wide; *upper surface* tomentose, tomentum characteristically forming a compact layer, often strigose toward the base, smooth or folded; *hymenial surface* usually covered with numerous, complex, branching radiate folds which vary from obtuse to acute, smooth or warted to spiny with obtuse spines, generally these are scattered; *stipes*, when present, rounded or flattened, may be lighter in color than the pileus, concolorous, or darker, in reality only prolongations of the thick, well-developed mycelia pad; *pad* 0.5–3 cm tall, 0.5–3 cm wide.

Tomental hyphae generally hyaline, with thickened walls, branching, clamped, 4–5 μ diam; cuticle of longitudinally parallel to slightly interwoven hyphae faintly pigmented; context with subsolid to solid, hyaline or yellowish hyphae, 4–5 μ diam, occasionally branched and clamped, more frequently branching solid hyphae toward the hymenium, 3–4 μ diam, thin-walled hyphae 3–4 μ diam. Hymenium with gloeocystidia 39–231 × 11–32 μ; basidia 22–30 × 5–6 μ, with 4 straight sterigmata; spores 3–4 × 2–3 μ; some basidioles with tapering apices.

Habitat: Dead wood.

Distribution: Pantropical.

Specimens examined: Argentina: *Speggazini* (NY); Brazil: *Manchet* TYPE of *Cladoderris candolleana* (PC), *Rick 101* (NY), *Rick* at Santa Cruz (NY), *Rick* no data (NY), *Traill 112* TYPE of *Beccariella trailii;* French Guiana: *Broadway 602* (NY); Dutch Guiana: *Samuel 45* (NY); Colombia: *Denton* (FH); Panamá: *Martin 3003* (NY, IA); Costa Rica: *Martin & Welden 8252* (NO, IA); Guatemala: *Kellerman 4603* (NY); British Honduras: *Peck* in 1906 (NY); Mexico: *Murrill & Murrill 775* (NY); Trinidad: *Britton & Britton 3593* (NO, NY); Grenada: *Broadway* (NY); Dominica: *Wakefield* (NY); Jamaica: *Lewis* (NO, IJ); *Murrill & Murrill* in Herb. Burt (FH), *Underwood & Earle 136* (NY), *Welden 455, 590, 747, 1021A, 1268, 1270, 1285* (NO).

CYMATODERMA FUSCUM (Cke.) Reid, Kew Bull. **1958**: 526. 1959; *Cladoderris fusca* Cke., Grevillea **10**: 123. 1892.

FIGS. 2B, 3B, 5A–F

Cladoderris glaziovii P. Henn. ex Sacc., Syll. Fung. **9**: 222. 1891. *Cladoderris floridana* Lloyd, Myc. Writ. 4. Myc. Notes, No. **39**: 535. 1915; *Cymatoderma fuscum* var.*floridanum* (Lloyd) Reid, Kew Bull. **1958**: 526. 1959.

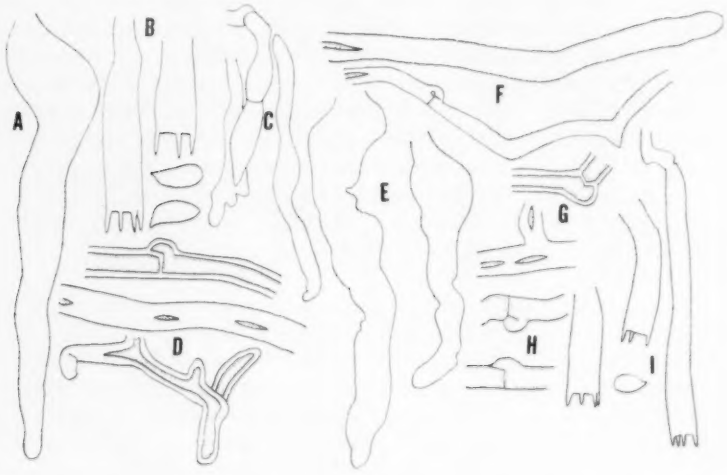

FIG. 4. A–D. *Cymatoderma caperatum* (Berk. et Mont.) Reid. A. Gloeocystidium. B. Basidia and spores. The three-sterigmate basidium probably has a fourth, collapsed sterigma. C. Sterile hymenial elements in the older portions of the hymenium. D. Various types of hyphae. The uppermost one is from the tomentum, the others are from the context. E–J. *Cymatoderma sclerotioides* (Lloyd) Reid. E. Two gloeocystidia. F. Contextual hyphae. G. Two hyphae from the tomentum. H. Two thin-walled contextual hyphae. I. Basidia and a spore. × ca. 1000.

Basidiocarp spongy-coriaceous to coriaceous, separate and then spathular, orbicular to flabelliform, or caespitose and then margins often fused giving a pseudoinfundibuliform appearance, when fresh Café-au-lait to French Nude (12 A 6, Maerz & Paul, ed. 2) to near Rose Amber (12 C 9), becoming Cinnamon (12 F 7) to dark brown with a blackish margin in herbarium, sessile to stipitate, 2–10 cm tall, 4–10 cm wide; *upper surface* smooth to radiately rugose, faintly zoned, with abundant tomentum that may be scantily developed toward the margin, zones near Rose Amber or darker; *hymenial surface* with radiate folds which branch

many times toward the margin and are densely covered, except at the margin, with numerous papillae, color similar to upper surface when fresh but papillae may be purplish, in herbarium papillae may become yellowish giving an ochraceous cast to the hymenium; *stipe,* when present, concolorous with the upper surface, flattened or rounded, arising from a well-developed, reddish brown mycelial pad, when absent one or more pilei seated directly upon the pad; *flesh* pale brown to cinnamon.

Tomental hyphae yellowish brown, solid to subsolid, 4–5 μ diam, rarely branching, some only thickened and with clamps, apices often with thin walls and septate; cuticular hyphae similar to tomental hyphae, deeply pigmented; contextual hyphae solid to subsolid, pigmented hyphae 4–5 μ diam, with or without clamps, most abundant toward the cuticle, other solid to subsolid twisting hyphae branched or not, more abundant toward the hymenium, 2–3 μ diam, hyaline, thin-walled hyphae 2–3 μ diam, most abundant in central portion of context. Hymenium with characteristic gloeocystidia 11–110 × 7–8 μ; papillae caused by granule-incrusted hyphae and clusters of crystals which often project through or elevate the hymenium; basidia 22–28 × 3–4 μ, with 4 straight sterigmata; spores 3–4(–5) × 2–3(–4) μ.

Habitat: Dead wood.

Distribution: Brazil, Grenada, Florida, and Louisiana.

Specimens examined: Brazil: *Glaziov 13499* in Herb. Cke. (Kew) TYPE of *Cladoderris fusca;* Grenada: *Welden & Lemke 1536* (NO); Florida: *Bayard,* Lloyd Herb. 292 (BPI) TYPE of *Cladoderris floridana;* Louisiana: *Welden 1801,* leg. G. W. Martin (NO).

Reid recognizes *Cladoderris floridana* as a variety of *Cymatoderma fuscum* on a tentative basis. The recent collections of this species show considerable variation in stalk formation and length, and the differences in spore sizes do not appear significant. I feel we are dealing with a single variable taxon. The rare collection of this species from scattered localities indicates its wide distribution. The Grenada and Louisiana material was found during very wet weather following semidrought to drought conditions. Perhaps this may help to account for its sporadic appearance.

CYMATODERMA SCLEROTIOIDES (Lloyd) Reid, Kew Bull. **1958**: 528. 1959; *Stereum sclerotioides* Lloyd, Myc. Writ. **7**: 115. 1922.
FIGS. 2A, 4E–I

Basidiocarp coriaceous, yellowish brown with a fawn colored hymenium when fresh, slightly darker in the herbarium, separate to caespitose, stipitate, arising from a distinct sclerotium (although the Panama collection lacks a sclerotium this was undoubtedly a collecting accident),

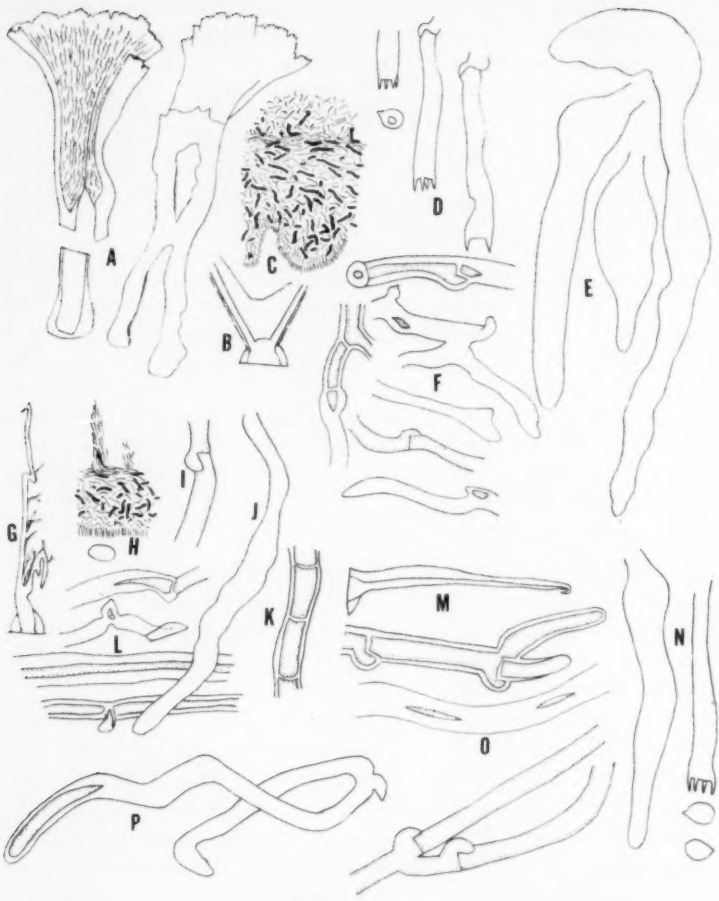

FIG. 5, A–P.

FIG. 5. A–F. *Cymatoderma fuscum* (Cke.) Reid. A. Habit sketches. Upper left is the hymenial surface. Lower left shows the mycelial pad surrounding the central "core." To the right is the upper surface of an entire stipitate fructification. B. A section through a pseudoinfundibuliform, sessile sporocarp showing the pad and central "core." C. A schematic section through the pileus. The dark lines represent solid hyphae. D. Basidia and a spore. E. Gloeocystidia. F. Various types of hyphae. The uppermost one is from the tomentum, the others are from the context of the sporocarp. G–L. *Cymatoderma cristatum* (Berk. et Curt.) Welden. G. A schematic section through a sporocarp. H. A schematic section through the pileus. The dark lines represent solid hyphae. To the left of H is a spore. I. A clamped, thin-walled hypha from the context. J. A gloeocystidium.

9 (TYPE)–11.5 cm tall, 2.5 (TYPE)–8 cm wide, spathulate to pseudo-infundibuliform due to fusion of two or more pilei arising from the same stipe; *upper surface* with many radiately folded, knifelike ridges which extend to the margin, tomentum weakly developed giving an olivaceous tint to the pileus when dry, more abundant toward the base (TYPE with well-developed tomentum of ochre brown); *hymenial surface* vinaceous cream, darker in TYPE, folds shallow, conspicuous in TYPE, smooth or with only a few, scattered warts; *stipe* long, strongly developed, covered with a reddish brown, velvety tomentum, concolorous with the upper surface or darker, separate or fused along their lengths, arising from a well-developed, dark brown sclerotium 4 × 2.5 cm, stipe 6–8 × 1 cm but swollen toward the base and expanding toward the pileus, hollow at the base in the Panama material.

Tomental hyphae loosely interwoven, solid, subsolid, and with thickened walls, branching occasionally, with or without clamp-connections, 3–5 μ diam; cuticular hyphae pigmented, solid to subsolid; contextual hyphae more tightly interwoven toward the hymenium, solid hyphae without clamps or branches 4–5 μ diam, solid or subsolid hyphae with short branches and clamps 2–4 μ diam, thin-walled hyphae 3–4 μ diam; sclerotial hyphae solid or subsolid, oriented in zones at right angles to one another. Hymenium with characteristic gloeocystidia, 50–80 × 5–10 μ; basidia (from TYPE) (22–)36–46 × 4–5 μ, with 4 straight sterigmata 2–4 μ long; a few spores from each collection measuring 4–5 × 3 μ.

Habitat: Panamá field notes report that collection as terrestrial. Perhaps it arises from a sclerotium on buried wood.

Distribution: Brazil, Panamá.

Specimens examined: Brazil: *C. Torrend*, Lloyd Herb. 26679, TYPE (BPI); Panamá: *Martin & Welden 8062* (NO).

SPECIES INCERTAE

Cladoderris membranacea deVries et Lév., Ann. Sci. Nat. III. **5**: 153. 1843.

Reid excludes this species as an effuso-reflexed stereoid fungus. I have examined a specimen collected by Miguel 1129 from Surinam (PC) which may be the type. The upper surface is spongy and covered with a thick, yellow buff tomentum; the lower surface is concolorous

K. A secondarily septate contextual hypha. L. Various types of contextual hyphae. M–P. *Cymatoderma dendriticum* (Pers.) Reid. M. A schematic section through a sporocarp. N. To the left a gloeocystidium, to the right a basidium, and below two spores. O. Various types of hyphae. The uppermost one is from the tomentum. The others are from the context of the sporocarp. P. Another contextual hypha. × ca. 1000.

with the upper except for scattered purplish tints. The hymenial configuration is typical of *Cymatoderma* and a few, scattered, blunt papillae are present. It is impossible to determine the width of the specimen since it has been cut, but it is 4 cm tall. A stipe is not present.

Microscopically gloeocystidia are present measuring 48–100 × 9–13 μ which are typical of *Cymatoderma*. Hyphal morphology and organization are also typical of this genus. The thin-walled hyphae are 4–5 μ diam, the solid ones 4–6 μ diam, and the narrow, solid, branched hyphae found more abundantly toward the hymenium are 3–4 μ diam. I did not observe basidia or spores. If this specimen proves to be the type then I believe the specimen to be *C. dendriticum*. All of the characters point toward that species. There is a note on the packet in a handwriting unknown to me which reads, "An a C. dendritica incipiente diversa?".

SPECIES EXCLUDENDAE

Cladoderris gausapata (Fr.) Fr., K. Sv. Vet.-Akad. Handl. **1848**: 142. 1849. This species is generally treated as *Stereum*.

Cladoderris platensis Speg., Anales del Museo Nacional de Buenas Aires **6**: 179. 1899. Reid considers this species a *Merulius*. I believe he is correct.

Cladoderris rickii Lloyd, Mycol. Writ. **7**: 1196. 1923. Again, Reid's disposition of this species as a *Merulius* appears to be the correct one.

RELATIONSHIPS OF OLD WORLD AND NEW WORLD SPECIES

While I have not studied the Afro-Asian species in detail, a few remarks on the distribution and affinities of these species may not be out of place. If *Cymatoderma lamellatum* (Berk. et Curt.) Reid is considered a valid species rather than a variety of *C. elegans* Jungh., and *C. africanum* Boidin (**2**) and *C. cristatum* are added to the genus, the total number of species of *Cymatoderma* is ten. Of these ten species one, *C. dendriticum,* is pantropical, four are exclusively new world and five are exclusively old world. *Cymatoderma africanum* and *C. plicatum* (Lloyd) Reid are African and Australian, respectively, *C. elegans* is Afro-Asian, *C. lamellatum* Australasian, and *C. blumei* (Lév.) Reid southeast Asian.

One of the most interesting anatomical facts which become evident in a comparison of these species is, while both old and new world species possess gloeocystidia, only the old world species, excepting *C. africanum,* are cystidiate with metuloids. These metuloids are thick-walled to solid,

hyaline to yellowish, ventricose with obtuse tips, obclavate, or ventricose-rostrate, and they are apically incrusted. There are several little-understood species in Asia and Africa such as *Stereum affine* Lév. (the Leiden, not the Paris portion), *S. mellesii* Lév., and *S. involutum* (Kl.) ex Fr. which possess similar metuloids. The other characteristics of these and several related species are similar to *Podoscypha*. Perhaps the same distribution of old world cystidiate and new world noncystidiate species obtains in *Podoscypha*. Boidin (**2**) has already transferred *S. involutum* into *Podoscypha*. Certain characteristics of the old world cystidiate Podoscyphas, such as a tightly interwoven cuticle, appear to overlap into *Cymatoderma*.

Certain widely disjunct species appear to be more closely related to one another than each is to other species having a similar distribution. The American *C. sclerotioides* and the African *C. africanum* arise from sclerotia; the only species in *Cymatoderma* to do so. These two species, and the ones discussed below may differ in one or two respects, but the total number of characters in common indicate a close relationship. The only significant microscopic difference between *C. africanum* and *C. sclerotioides* is in spore size; *C. africanum* has larger spores. From Boidin's drawings and descriptions, the only noteworthy macroscopic difference is the more ornate hymenium in *C. africanum*, but this character is variable and in one of the two collections of *C. sclerotioides* there are more hymenial folds than in the other. The American *C. caperatum* and the Australasian *C. lamellatum* are so closely similar that they have been confused in the literature. The pileus of *C. lamellatum*, according to Reid is ". . . pseudoinfundibuliform or perhaps even truly infundibuliform. . . ." In *C. caperatum* the pileus is infundibuliform but often one side is more highly developed than the other, and the spores of this species average larger than in *C. lamellatum*. The only two consistently papillate species of *Cymatoderma* are *C. fuscum* in the Americas and *C. elegans* in Africa and Asia. The spores of *C. elegans* tend to be larger than those of *C. fuscum*. Of the three remaining species *C. blumei* appears to stand alone, and *C. plicatum* and *C. cristatum* show affinities with the *C. lamellatum-C. caperatum* group.

Our present state of knowledge of the distribution of fungi, and the reasons for such distribution that we do know, do not permit any certain explanation for these "substitution species" (**3**, p. 266). These disjunctions can be partially explained by postulating a past continuous distribution. Instead of the separate species recognized today there may have been species complexes distributed pantropically. When geographic separation occurred those isolated in the new world differen-

tiated without metuloids, and those of the old world differentiated with metuloids.

The curators of the Rijksherbarium in Leiden, the Museum National d'Histoire Naturelle in Paris, and The New York Botanical Garden have been most generous with loans of historically important collections. I should like to express my appreciation to them for their many courtesies.

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SOIL FUNGI FROM COSTA RICA AND PANAMA

R. D. Goos

(WITH 1 FIGURE)

Although soil fungi from many areas of the world have been extensively studied (**7**), there have been relatively few investigations of the soil mycobiota in Central America. The most extensive work is that of Farrow (**5**), who isolated 135 species from the soils of Panama and Costa Rica. Sequeira (**16**), in an unpublished report, listed 48 species of fungi isolated from Costa Rican soils. Other investigations conducted in Central America were concerned primarily with the isolation of plant pathogenic fungi (**14**) or with a selected taxon (**15**).

This communication reports in part the results of a survey of fungi found in the rhizosphere of the commercial banana (*Musa*, AAA group, "Gros Michel") and in lowland banana soils of Central America, carried out in conjunction with studies on the *Fusarium* wilt of banana. Some species are reported that were not recorded by Farrow (**5**) and this paper may be considered as supplementary to his work.

MATERIALS AND METHODS

Soil and root samples were collected in three localities near Coto (Prov. Puntarenas), Costa Rica (FIG. 1). Root samples were obtained in Zapote Farm, Chiriqui Land Company,[1] Armuelles, Panama, and in Farm 44, Ciá. Bananera de Costa Rica,[1] during April, 1958. Farm 44 had been largely abandoned for banana production due to *Fusarium* wilt, but small areas remained in production. Root samples were taken from the survivors. Zapote Farm was an area in which bananas had been in continuous production for many years and was essentially free of disease. Root samples consisted of segments 20–30 cm in length, taken immediately basal to the region of elongation. Soil remaining on the roots after gentle shaking was considered to be rhizosphere soil. Suspensions of rhizosphere soil were obtained by washing the roots in sterile distilled water and were used to prepare dilution plates.

[1] Subsidiaries of United Fruit Company.

Soil samples were collected during June, 1958, in a virgin forest area (now Farm 55, Golfito Division), which was being prepared for banana planting. Native forest had been felled on this area five years before the collecting date, and secondary growth had been cut during the preceding five months. Samples were collected by plunging the open end of a sterile test tube into the vertical wall of a collecting pit. The tubes were then plugged with sterile cotton and wrapped in "Parafilm" [2] to retain moisture, and stored for a three month period before analysis. This period of storage undoubtedly had some effect on the fungi present in the samples (**18**).

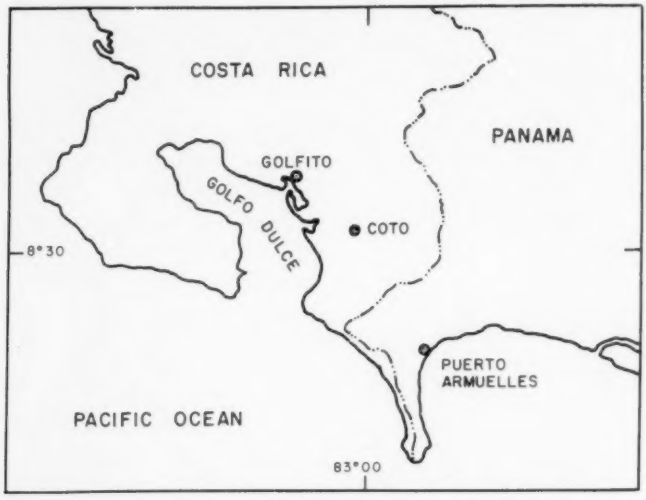

FIG. 1. A map of the Coto area of Costa Rica.

Most isolations were made from soil-dilution plates prepared with Martin's (**9**) rose bengal-streptomycin agar. A few isolations were made from root segments plated directly on aqueous agar. All isolates reported were established in pure culture and were subcultured on various media for identification purposes.

RESULTS

A total of 47 species belonging to 33 genera were isolated and identified in this survey. The species were divided as follows: Acrasiae—1,

[2] Parafilm manufactured by Marathon, a Division of American Can Company, Menasha, Wisconsin.

TABLE I

FUNGI IDENTIFIED FROM SAMPLES OF COSTA RICAN AND PANAMANIAN SOILS

Fungus	Banana rhizosphere soil		Virgin forest soil
Aspergillus clavatus Desm.		x[1]	
Aspergillus conicus Blochwitz		x	
Aspergillus janus Raper & Thom			x
Aspergillus luchuensis Inui	x[2]	x	
Aspergillus niger van Tieghem*		x	
Aspergillus sclerotiorum Huber	x		
Aspergillus terreus Thom*			x
Cephalosporium sp.	x	x	x
Chaetoceratostoma longirostre Farrow		x	x
Choanephora cucurbitarum (Berk. & Rav.) Thaxt.*		x	
Cladosporium herbarum (Pers.) Link*	x	x	x
Cunninghamella echinulata Thaxt.	x	x	
Cunninghamella elegans Lendner	x	x	
Curvularia lunata (Walker) Boed.*		x	
Cylindrocarpon sp.			x
Delacroixia coronata (Constantin) Sacc. & Syd.*	x	x	
Dictyostelium mucoroides Bref.		x	
Dothiorella sp.	x		
Fusarium moniliforme Sheld.*		x	
Fusarium roseum Link emend. Snyd. & Hansen*	x	x	
Fusarium solani (Mart.) App. & Wr. emend. S. & H.*	x	x	
Geotrichum candidum Link		x	x
Gliomastix convoluta (Harz) Mason			x
Humicola sp.			x
Memnoniella echinata (Riv.) Galloway	x		
Mucor hiemalis Wehmer	x	x	
Myrothecium roridum Tode ex Fries	x	x	x
Neurospora crassa Shear & Dodge		x	
Nigrospora sphaerica (Sacc.) Mason		x	
Paecilomyces varioti Bainier	x	x	
Penicillium asperum (Shear) Raper & Thom	x	x	
Penicillium avellaneum Thom & Turreson		x	
Penicillium funiculosum Thom		x	
Penicillium lilacinum Thom	x	x	x
Penicillium oxalicum Currie & Thom	x		
Penicillium simplissimum (Oud.) Thom	x		
Penicillium vermiculatum Dangeard	x		
Phialophora sp.			x
Phoma sp.	x	x	
Phomopsis sp.	x		
Pyrenochaeta sp.	x		
Sphaerostilbe repens Berk. & Br.			x
Stachybotrys atra Corda*	x		
Staphylotrichum coccosporum Nicot & Meyer			x
Torula sp.	x		
Trichoderma viride Pers. ex Fries*	x	x	x
Verticillium sp.		x	
Volutella sp.		x	

[1] Farm 44.
[2] Zapote Farm.
* Species reported by Sequeira (16).

Phycomycetes—5, Ascomycetes—6, Fungi Imperfecti—35. No basidiomycetes were isolated. The fungi identified and the area in which each was located are shown in TABLE I. A number of nonsporulating forms were isolated, but could not be identified and are not listed.

DISCUSSION

Members of the Acrasiae are rarely reported in lists of soil fungi, although, according to Raper and Thom (**13**), they are common in soil and surface litter. In this survey, a single isolation of *Dictyostelium mucoroides* was made from a root segment plated on aqueous agar. Farrow (**5**) reported this organism from soils of Panama, and Agnihothrudu (**1**) has reported the occurrence of several species of *Dictyostelium* in the rhizosphere of plants in India. Warcup (**21**) and Singh (**17**) reported isolating *Dictyostelium* from soil in England, and Rai and Tewari (**12**) found *D. mucoroides* as well as *Polysphondylium violaceum* Bref. in Indian soils. As Farrow (**5**) has pointed out, the media used for the isolation of fungi do not favor the Acrasiae, and this probably accounts for the absence of these organisms in most studies of soil fungi.

Two rare species of *Aspergillus* were found. These were *A. conicus* and *A. janus*. *A. conicus* has previously been reported from soil in England (**3**) and is unique among the Aspergilli because of the slimy character of its spores. *A. janus* has been isolated on several occasions from soils collected in Panama (**20**) but has not been reported from other countries. The isolate recorded here was obtained from a soil sample collected in Costa Rica at a location close to the Panamanian border. Thom and Raper (**20**) concluded that *A. janus* "represents a normal component of the microflora of Panama." Its isolation from soil in neighboring Costa Rica supports this view and suggests that the fungus may have a wider distribution in Central America.

A fungus identified as *Delacroixia coronata* (= *Conidiobolus villosus* Martin) was isolated from several samples of rhizosphere soil obtained from roots growing in the upper soil layers, particularly from those growing in surface litter. Gilman (**7**) does not list *D. coronata* as a soil inhabitant, although Drechsler (**4**) has reported that it may be readily isolated from plant detritus decaying in soil.

The isolation of *Sphaerostilbe repens* from Costa Rican soil has been reported in a previous paper (**8**). This fungus has also been found in soils of Honduras and has been reported from soil in the Belgian Congo by Meyer (**10**). It appears to be widespread in tropical areas.

Staphylotrichum coccosporum was described in 1956 by Nicot and

Meyer (11) and reported as common in soils and leaf litter in Central Africa. Single isolations have also been reported from Mexico (11) and from Thailand (Nicot; personal communication). The range of this fungus has now been extended to Costa Rica. The identity of the isolate recorded here was confirmed by Mme. Nicot.

Chaetoceratostoma longirostre was found in the two Costa Rican localities sampled in this survey and has since been found in banana soils from Honduras. Farrow (6) isolated this fungus from several soils collected in Panama and described it as a new species, and it has since been reported from Indian soils by Agnihothrudu (2).

Although three species of *Fusarium* were isolated from the rhizosphere of banana roots, *F. oxysporum* Schlecht. was not found. This is of interest, inasmuch as banana production in one sampling area (Farm 44) had been largely abandoned due to a wilt disease caused by *Fusarium oxysporum* f. *cubense* (E.F.S.) Snyd. & Hans. This observation is consistent, however, with the experience of Stover (19), who found that the soil dilution technique was unsatisfactory for isolating *F. oxysporum* from soil.

Several fungi found in the virgin forest soil were not present in either of the other sampling areas. This may have been, in part, a reflection of the diverse vegetation present in this area before the sampling date. No phycomycetes were isolated from the virgin soil, which is of interest, inasmuch as these fungi are generally abundant in soil and are among the most readily isolated. Their absence from this soil may have been the result of the long storage period to which the samples were subjected, as storage has been shown to have marked effects on soil microbial populations (18).

It is evident from this limited survey that many little-known and interesting fungi may be found in the soils of Central America. The work reported here was based on relatively few samples and the use of a single isolation medium. A more extensive study, employing a greater variety of media, would doubtlessly reveal many additional fungi.

SUMMARY

A survey was made of fungi occurring in the rhizosphere of Gros Michel banana in Panama and Costa Rica, and in a virgin forest soil from Costa Rica. A total of thirty-three genera and forty-seven species were isolated, among them *Dictyostelium mucoroides, Sphaerostilbe repens, Staphylotrichum coccosporum, Delacroixia coronata* and *Aspergillus janus*. The occurrence of these fungi in soils is discussed. Al-

though some samples were taken from an area in which banana production had been abandoned because of *Fusarium* wilt, the wilt pathogen, *Fusarium oxysporum* f. *cubense,* was not found in any of the areas sampled.

ACKNOWLEDGMENTS

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A TAXONOMIC ANALYSIS OF SECTION ATHELE OF THE GENUS CORTICIUM. I. GENUS XENASMA [1]

ANTHONY E. LIBERTA [2]

(WITH 20 FIGURES)

C. H. Persoon, in 1794, erected the genus *Corticium,* describing it in the terms "pileo obliterato, hymenio effuso resupinato toto adnexo." In 1796, he expanded the generic description to "effusum, substantia varium, totum adnexum; pileus inconspicuus, obliteratus, hymenium hinc resupinatum laeviusculum, papillisque obtutum." S. F. Gray's transfer of *Thelephora quercina* Pers. to *Corticium* amounted to typification of the genus in 1821.

In 1879, M. C. Cooke created a nomenclatural problem when he based his genus *Peniophora* on the type of *Corticium.* In addition, the acceptance of *Peniophora* and the enlargement of the concepts of this genus by most later workers led to the placing of cystidiate forms in *Peniophora,* and noncystidiate forms in *Corticium.* Other characteristics which might have been of greater taxonomic importance were not fully considered, and the result was an agglomeration of unrelated species in both genera.

Bourdot & Galzin (**1911**) made one of the first attempts to segment *Corticium* by establishing "Groupes" or "Sections," each composed of what seemed to be closely related species. Although not altogether natural, these sections are at least convenient.

One of these sections was section *Athele,* and it was described by Bourdot & Galzin (**1928**) as follows: "Ceraceous or subpellicular, dry,

[1] Based on a portion of a thesis submitted to the Graduate College of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] I acknowledge with deepest gratitude the encouragement and guidance of Dr. Donald P. Rogers. He introduced me to the thelephoraceous basidiomycetes and made available his accumulated materials. Special thanks are extended to Dr. Luella K. Weresub for critically reading the manuscript. Material for this study was borrowed from the herbaria of the Museum National d'Histoire Naturelle in Paris, the Farlow Herbarium at Harvard, the Royal Botanic Gardens at Kew, the University of Toronto, Dr. John Eriksson, and Dr. D. P. Rogers.

adherent, trama formed of few hyphae, short or more often indistinct; spores generally clinging together in groups of 2–4, species living especially on dry wood or herbaceous debris, rarely on very decayed wood. The hyphae are fairly distinct in the first five species, generally indistinct in the others."

H. S. Jackson (**1950a**) suggested that the *Peniophora rimicola* group, composed of *P. rimicola* (Karst.) Höhn. & Litsch., *P. pruinosa* (Pat.) Jackson, *P. pulverulenta* (Litsch.) Jackson, and *P. praeterita* Jackson, was closely related to "the more characteristic members" of section *Athele* because of the manner of growth and the method of basidial development. *Corticium Aurora* Berk. & Br., *C. juncicolum* Bourd., *C. filicinum* Bourd., and *C. Lloydii* Bourd. & Galz. were the four species considered by Jackson (**1950b**) as the more characteristic members.

Using the *Peniophora rimicola* group as a nucleus, M. A. Donk (**1957**) erected the genus *Xenasma* with *P. rimicola* as the type species. In the generic description, the hyphae were described as "slender, the walls thin and gelatinised . . . parallel to the substratum, indistinct." The basidia were described as being scattered in the hymenium and "reposing directly on the subicular layer usually with hidden bases (pleurobasidious)."

Pleurobasidia are typically found in species whose basidiocarp consists almost entirely of prostrate hyphae, from which these basidia arise as perpendicular, or lateral, swellings. This type of development results in a two-rooted, or bifurcate, basidial base that lacks a basal septum, and in some instances, additional basal extensions produce a final effect of a several-rooted basidium.

Although Donk included this type of basidium in the generic description of *Xenasma,* he cautioned against overrating its taxonomic significance, reporting that in species which eventually produce a thick hymenium, such as *Peniophora aurantiaca* (Bres.) Höhn. & Litsch., some of the first basidia to form are pleurobasidious while all later basidia develop "normally." A similar condition was described in *Tubulicrinis accedens* (Bourd. & Galz.) Donk by L. K. Weresub (**1957**).

The primary concern of the present analysis has been to restudy section *Athele* and determine which of its members have affinities in the genus *Xenasma.* The combination of characteristics which appear to be taxonomically significant in determining these affinities is: the method of basidial development, the basidial morphology, and the condition of the hyphae. Therefore, as herein delimited, *Xenasma* includes only those species possessing basidia that are produced almost exclusively as lateral extensions of the prostrate hyphae. Such basidia are cylindro-

clavate and have a rooted base that lacks a basal septum. In some species now included in the genus, terminal basidia occasionally occur, but these are solitary on short upright hyphae or merely the result of the transformation of an upturned tip of a prostrate hypha into a basidium. In addition, when sterile structures such as cystidia, cystidioles, or gloeocystidia are present, these too are quite often produced as a perpendicular swelling of a prostrate hypha. The hyphae are mostly parallel to the substratum, and although these may be distinct and loosely interwoven when first formed, they either become conglutinate with the walls remaining distinct, or become an amorphous matrix as the result of hyphal wall gelatinization.

Only the members of section *Athele* whose affinities appear to lie in the genus *Xenasma* will be discussed at this time. The remaining members of the section will be considered in a subsequent paper. Several species which have been suggested at one time or other as belonging to either section *Athele* or to *Xenasma* are also discussed at this time.

Drawings were made from slide preparations stained in 0.5 N NH_4OH and Congo Red. This concentration of ammonium hydroxide was found to be quite adequate in promoting swelling of dried material, yet less violent than KOH in its dissolving properties. Melzer's solution was used to determine amyloidity and for study of structures eventually soluble in ammonium hydroxide; sulfuric-benzaldehyde, as recommended by Boidin (**1951**), was used to determine the presence of positively reacting gloeocystidia or test the reaction of previously described gloeocystidia.

Colors given with the initial letter capitalized are in accordance with Ridgway's *Color Standards*. Names of herbaria are abbreviated as in the fourth edition of the *Index Herbariorum*, the brackets indicating the location of the specimens cited. The sign (!!) following a binomial indicates that the type or lectotype was examined, while the sign (!) indicates that authentic material was seen. Brackets ([ ]) around dates are used where a correct date has been substituted for that carried on a title page.

XENASMA Donk, Fungus **27**: 25. 1957.

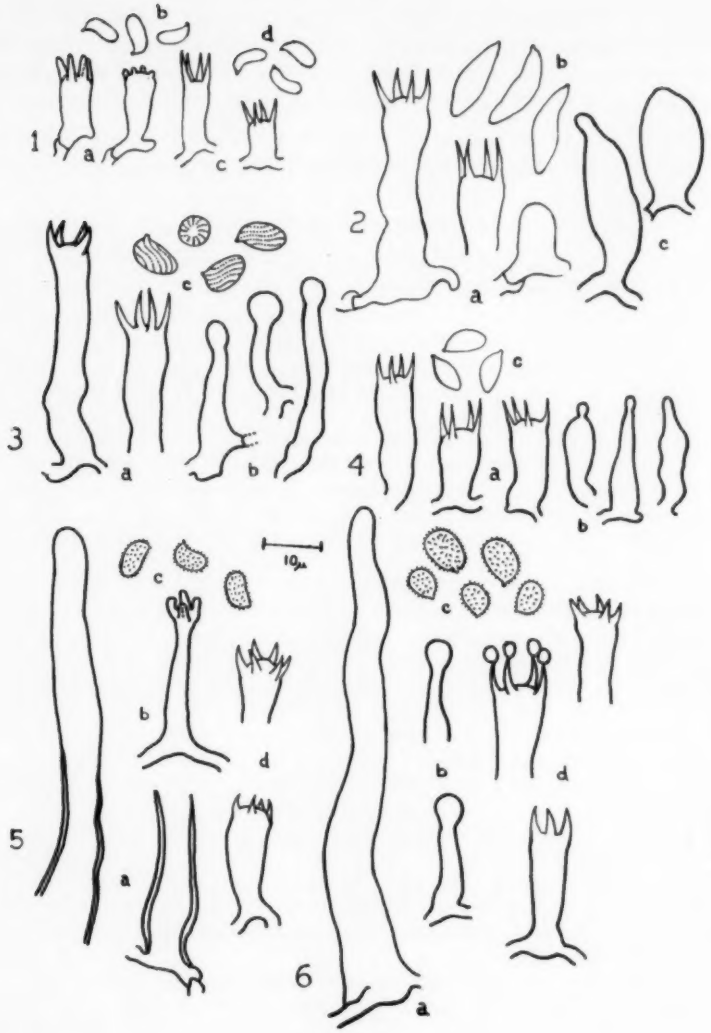
Fructification resupinate, effused, usually very thin, soft-ceraceous to gelatinous, drying to a vernicose film, under a lens usually appearing pruinose or pulverulent, adnate; subiculum thin to rather thick, composed of indistinct, thin-walled hyphae that are conglutinate, or the walls becoming gelatinized; cystidia, cystidioles, or gloeocystidia present or absent, the walls thin or thick, usually arising as a perpendicular

extension of the prostrate hyphae; basidia scattered, cylindrical to subclavate, usually arising as lateral extensions of prostrate hyphae, the base nonseptate, two-rooted or several-rooted (pleurobasidious); sterigmata 2–7; spores hyaline, the wall smooth or roughened, amyloid or nonamyloid.

TYPE: *Peniophora rimicola* (Karst.) Höhn. & Litsch.

KEY TO SPECIES

a. Spores slightly amyloid, ellipsoid to suballantoid or allantoid, 5–6.5 × 2–3.5 μ; basidia 7.5–16(–24) × 4–5(–6) μ.....1. *X. rallum*
a. Spores nonamyloid.....b
b. Cystidia, cystidioles, or gloeocystidia present.....c
b. Cystidia, cystidioles, or gleocystidia absent.....l
c. Gloeocystidia present, staining in sulfuric-benzaldehyde; spores smooth, subclavate, 12–18.5 × 3–4.5 μ.....2. *X. Aurora*
c. Gleocystidia absent, cystidia or cystidioles present.....d
d. Cystidia, or both cystidia and cystidioles present.....e
d. Cystidia lacking, cystidioles present.....f
e. Cystidia and cystidioles present.....g
e. Cystidia present, cystidioles lacking, the walls of the cystidia thick, lamellate.....i
f. Cystidioles capitate; spores ellipsoid, 8–12 × 4.5–6 μ, wall markings in longitudinal spiral lines, not evident in KOH or NH_4OH...3. *X. pulverulentum*
f. Cystidioles with an elongate projection at the apex; spores oblong-ellipsoid to subfusiform, 6–9.5 × 3–4.5 μ, the wall smooth..4. *X. albo-glaucum*
g. Cystidioles lobed at the apex; basidia bearing five to six sterigmata; spores ellipsoid, laterally depressed, 5–7 × 3–4 μ, the spore wall minutely asperulate, the markings not evident in KOH or NH_4OH.....5. *X. pruinosum*
g. Cystidioles simple or capitate.....h
h. Cystidia with thin walls throughout; basidia bearing three to five sterigmata; spores broadly ellipsoid to subglobose, (5.5–)7–9 × (4.5–)6–7 μ, the spore wall minutely asperulate, the markings persistent in KOH and NH_4OH.....6. *X. praeteritum*
h. Cystidia with thickened walls at the base; basidia bearing two to four sterigmata; spores broadly ellipsoid to obovate, (6.5–)8.5–10.5 × (3.5–)4.5–7 μ, the spore wall minutely asperulate, the markings not evident in KOH or NH_4OH.....7. *X. rimicola*
i. Cystidial wall externally roughened; paraphysoid hyphae present, with caps of acicular crystals; spores globose to obovate, (4–)5–9 × (4–)4.5–7.5 μ, the wall asperulate.....8. *X. clematidis*
i. Cystidia usually sheathed in dendritic hyphae; the spore wall smooth.....j
j. Cystidia up to 15 μ broad above the base; spores lunate to falcate, 7.5–14 × 4.5 μ.....9. *X. Dussii*
j. Cystidia broader than 15 μ above the base.....k
k. Spores oblong-cylindrical or oblong-ellipsoid to broadly subnavicular, 12–19 × 4.5–7 μ.....10. *X. macrosporum*
k. Spores flexuous navicular, 12–30 × 3.5–5 μ.....11. *X. vermiferum*



FIGS. 1–6.

FIG. 1. *Xenasma rallum*, a: basidia, b: spores, from TRTC 17825; c: basidia, d: spores, from D. P. Rogers 290. FIG. 2. *X. Aurora*, a: basidia, b: spores, c: gloeocystidia, from Bourd. 29765. FIG. 3. *X. pulverulentum*, a: basidia, b: cystidioles, c: spores, from TRTC 23200. FIG. 4. *X. albo-glaucum*, a: basidia, b: cystidioles, from TRTC 17603; c: spores, from TRTC 16288. FIG. 5. *X. pruino-*

l. Basidia bearing two large sterigmata; spores turbinate with five tubercles at the apex, 5–9 × 4.5–8 μ.....12. *X. ludibundum*
l. Basidia bearing four sterigmata.....m
m. Spores finely asperulate.....n
m. Spores smooth.....p
n. Spores globose or subglobose to obovate, 3.5–6 × 3–6 μ; basidia 9–17 (–20) × 5–8 μ; sterigmata (3–)3.5–6(–9) μ long.....13. *X. tulasnelloideum*
n. Spores ellipsoid or ovoid; basidia 6 μ or less in width.....o
o. Spores ellipsoid, straight on one side, 4–4.5 × 2–2.5 μ; basidia 8.5–13 (–15) × 4–6 μ; sterigmata 1.5–3.5 μ long.....14. *X. insperatum*
o. Spores ellipsoid or ovoid, occasionally laterally depressed near the apiculus, 4–5 × 2.5–3 μ; basidia 10–14 × 4–5 μ; sterigmata 3.5–8 μ long.....15. *X. tenuiculum*
p. Fructification Light Brownish Olive; basidia ellipsoid-subcylindrical, externally surrounded by brownish-olive granules; spores oblong-ellipsoid to suballantoid.....16. *X. Lloydii*
p. Fructification and basidia not as above.....q
q. Basidia 11–26 × 5–7.5(–8) μ; sterigmata 2.5–6(–8) μ long; spores obovate or broadly ellipsoid to subellipsoid-navicular, 5–10.5 × 3–5 μ....17. *X. filicinum*
q. Basidia 20 μ or less in length.....r
r. Basidia 13–20 × 5–6 μ; sterigmata 3–4.5 μ long; spores obovate or oblong and abruptly attenuated at the base.....18. *X. thymicola*
r. Basidia 15 μ or less in length.....s
s. Spores obovate to broadly oblong-ellipsoid, 5–7(–7.5) × 3.5–4.5(–5) μ; basidia (8–)9.5–14 × (4.5–)5–7 μ.....19. *X. subnitens*
s. Spores oblong-ellipsoid and laterally depressed to short-allantoid, 4–4.5 × 2.5–3 μ.....20. *X. grisellum*

1. **Xenasma rallum** (Jackson) Liberta, comb. nov. FIG. 1
Corticium rallum Jackson, Can. Jour. Res. 28(C): 723, *fig. 8.* 1950(!!).

Fructification effused, thin, in section 20–60 μ thick, gray or bluish-gray to light buff, subceraceous, under a lens appearing waxy-pruinose, closely adnate; subiculum either inconspicuous and giving rise to short, upright, nodulose hyphae, or rather thick and composed of hyphae parallel to the substratum, nodose-septate, 1–2.5 μ in diam, conglutinate or the walls becoming gelatinized; basidia cylindrical to subclavate, the base bifurcate, often obscure, 7.5–16(–24) × 4–5(–6) μ, bearing four erect, subulate sterigmata 4–7.5 μ long; basidiospores hyaline, the wall smooth, weakly amyloid, ellipsoid and laterally depressed to suballantoid or allantoid, 5–6.5 × 2–3.5 μ.

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sum, a: cystidium and cystidial base, b: cystidiole, c: spores, d: basidia, from V. Litsch. 8.VIII.1929. FIG. 6. *X. praeteritum,* a: cystidium, b: cystidioles, c: spores, d: basidia, from TRTC 17598.

On decayed wood and bark of *Picea sitchensis, Pseudotsuga taxifolia, Tsuga canadensis, Castanea grandidentata, Quercus macrocarpa, Vitis vulpina, Acer,* and *Fraxinus.* Known from British Columbia, Ontario, Iowa, Massachusetts, New York, Oregon, and Rhode Island.

Specimens examined: British Columbia: *W. G. Ziller* (V 4805; DAOM 31868).

Ontario: *H. S. Jackson* (TRTC 17825, 18717 TYPE).

Iowa: *D. P. Rogers 49, 290* (TRTC), *711; L. W. Miller* (D.P.R. 228).

Massachusetts: *D. H. Linder* (D.P.R. 741; FH; TRTC), (D.P.R. 742; FH).

New York: *D.H.L.* (D.P.R. 743; FH).

Oregon: *A. M. & D. P. Rogers 596.*

Rhode Island: *A. M. & D. P. R. 3903* (TRTC).

Although at the present time, this species is the only member of *Xenasma* possessing amyloid spores, it is included because it coincides with other members in all characteristics herein considered to be taxonomically significant. To exclude it would be to ignore these significant features. In Donk's (**1957**) generic description, the spores of *Xenasma* were described as nonamyloid. In the present study, his generic description has been expanded to include the character of spore amyloidity.

The collections from Massachusetts, New York, and Oregon differ somewhat from the type. The spores in these collections are predominantly allantoid rather than ellipsoid with one side depressed, and the basidia are shorter than those of the type. However, the collection from Iowa, *D. P. Rogers 290,* possesses both spore types and both basidial types. Thus, there is little doubt that the collections from Massachusetts, New York, and Oregon are *Xenasma rallum* rather than a separate species.

2. **Xenasma Aurora** (Berk. & Br.) Liberta, comb. nov. FIG. 2

Corticium Aurora Berk. & Br. Outl. Brit. Fungol. p. 276. 1860 (!!); M. C. Cooke, Handb. Brit. Fungi **1**: 326. 1871; Fries, Hym. Eur. p. 657. 1874; J. Stevenson, Brit. Fungi **2**: 281. 1886; Massee, Linn. Soc. Bot. Jour. **27**: 141. 1890; Höhn. & Litsch., Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. **115** (Abt. I): 1552. 1906; W. G. Smith, Synop. Brit. Basidio. p. 413. 1908; Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 251. 1911; Hym. Fr. p. 209. *fig. 62.* 1928; Talbot, Bothalia **6**: 18. 1951.

Corticium juncicolum Bourd., Rev. Sci. Bourb. **23**: 11. 1910 (p. 9 of repr., 1910) (!!); Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 251. 1911; Hym. Fr. p. 209. *fig. 63.* 1928 (as "subsp." under *C. Aurora*).

Fructification effused, thin, in section 36–60 μ thick, white or Cartridge Buff to Cream Buff, waxy-pruinose or waxy-farinose to waxy-submembranous, the margins pruinose to farinose, adnate; hyphae mostly parallel to the substratum, nodose-septate, 1.5–7 μ in diam, conglutinate or the walls becoming gelatinized; gloeocystidia irregular, staining in sulfuric-benzaldehyde, the base often bifurcate or obscure, up to 37 μ long and 15 μ broad; basidia cylindrical to subclavate, occasionally flexuous, borne directly on the horizontal hyphae, the base bifurcate, often obscure, 24–44.5 × 6–10.5(–12) μ, bearing four slender sterigmata 5–7.5(–8) μ long; basidiospores hyaline, the wall smooth, non-amyloid, subclavate, slightly curved, attenuating gradually toward the base and more abruptly toward the obtuse apex, 12–18.5 × 3–4.5 μ.

On dead leaves and stems of *Juncus effusus* and *Carex*. Known from England and France.

Specimens examined: England: Batheaston, 2.XII.1851 (K), TYPE. France: Mas de Barthe, Aveyron, 5.IX.1909, *Galz. 4480* (Bourd. 7456; PC); Marais de Frégefont, Tarn, 5.IX.1909, *Galz. 4527* (Bourd. 7457; PC); 18.VI. 1910, ex herb Bres. (K); St. Priest, Allier, 17.VII. 1911, *Bourd. 29765* (PC); Mas de Barthe, Aveyron, *Galz. 7128* (TYPE of *C. juncicolum;* PC).

The characteristics which readily distinguish this species from other members of this genus are the large subclavate spores and gloeocystidia, the latter previously undescribed. These gloeocystidia are quite prominent in preparations stained with either ammonium hydroxide and Congo Red or sulfuric-benzaldehyde.

Massee's (**1890**) description of the spores as "ellipsoid, basally apiculate, 10–11 × 7–8 μ" does not agree with the collections studied, either in spore morphology or size. His description led Höhnel & Litschauer (**1906**) to consider *Corticium Aurora* as synonymous with *C. laetum* (Karst.) Bres. The differences between *C. Aurora* and *C. laetum,* both in texture and spore morphology, are discussed by Talbot (**1951**) who, along with Bourdot & Galzin (**1928**), disagrees with the proposed synonymy of Höhnel & Litschauer.

Corticium juncicolum was first described by Bourdot (**1910**) as a distinct species, but its apparent close affinity to *C. Aurora* prompted Bourdot & Galzin (**1928**) to reduce *C. juncicolum* to subspecific rank under *C. Aurora.* This analysis has revealed that *C. juncicolum* coin-

cides with *C. Aurora* in all respects, including the presence of gloeocystidia. Therefore, *C. juncicolum* is herein reduced to synonymy.

Since none of the species originally included in *Xenasma* by Donk (**1957**) possessed gloeocystidia, this character was not included in his generic description. In the present study, the generic description has been expanded to include this character.

3. XENASMA PULVERULENTUM (Litsch.) Donk, Fungus **27**: 25. 1957. FIG. 3

Corticium pulverulentum Litsch., Österr. Bot. Zeits. **88**: 112. *fig. 2.* 1939.

Peniophora pulverulenta (Litsch.) Jackson, Can. Jour. Res. **28**(C): 532. *fig. 3.* 1950 (!); J. Boidin, Rev. de Mycologie, Mémoire hor-séries **6**: 119. *fig. 34.* 1958.

Fructification effused, thin in section 20–30 μ thick, when fresh hyaline to bluish-gray, cartilaginous-gelatinous, drying to a whitish to bluish-gray vernicose film, under a lens the surface appearing pruinose, closely adnate; hyphae parallel to the substratum, nodose-septate, 2–3 μ in diam, conglutinate or the walls becoming gelatinized; cystidioles thin-walled, cylindrical or somewhat subulate, simple or capitate, 16–37 $\times$ 3–3.5(–4) μ, the apical bulb 4.5–5(–6) μ in diam; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 20–42 $\times$ 5.5–8 μ, bearing four arcuate sterigmata 4–5 $\times$ 1.5–2 μ; basidiospores hyaline, the wall bearing longitudinal markings arranged in a broad spiral, the marking evident in Melzer's solution, disappearing in KOH or NH_4OH, nonamyloid, ellipsoid, slightly depressed on one side, 8–12 $\times$ 4.5–6 μ.

On decayed bark and wood of *Fagus grandifolia, Fraxinus excelsior, Tilia americana, Tsuga canadensis, Cornus,* and *Quercus.* Known from Austria, France, and Ontario.

Specimens examined: Ontario: *H. S. Jackson* (TRTC 16698, 17582, 17710, 18656, 19122, 22437, 22438, 23200).

4. **Xenasma albo-glaucum** (Bourd. & Galz.) Liberta, comb. nov. FIG. 4

Corticium albo-glaucum Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 251. 1911 (!!).

Corticium expallens Bres. var. *albo-glaucum* Bourd. & Galz., Hym. Fr. p. 214. 1928.

Fructification effused or irregularly maculiform, in section 20–130 μ thick, white or Cartridge Buff to Cream-Buff, arid-ceraceous to cera-

ceous-glaucous, often cracked, under a lens appearing ceraceous-pruinose or ceraceous-pulverulent to occasionally ceraceous-membranous, adnate; hyphae mostly parallel to the substratum, clamp connections rare, 1.5–3.5 μ in diam, conglutinate or the walls becoming gelatinized; cystidioles subcylindrical, subulate, or ventricose-subulate, not projecting or projecting only a few microns, very often bearing a small elongate or spherical projection at the apex, 13.5–24.5 × 3–5(–7.5) μ; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, often obscure, or occasionally terminal on short upright hyphae, 12–25 × 4.5–7.5 μ, bearing four slender sterigmata, 3–5(–6) μ long; basidiospores hyaline, the wall smooth, nonamyloid, oblong-ellipsoid to subnavicular or subfusiform, 6–9.5 × 3–4.5 μ, often clinging together in groups of two or four.

On decayed wood and bark of *Salix alba* and *Acer*. Known from France, Ontario, and Ohio.

Specimens examined: France: St. Priest, Allier, 13.VII.1910, *Bourd. 7349* (PC), LECTOTYPE.

Ontario: *H. S. Jackson* (TRTC 16262, 16288, 17445, 17603).

Ohio: *C. G. Lloyd 07372* (TRTC 18115).

This species is easily distinguished from other members of *Xenasma* by its cystidioles, which Jackson (**1950b**) considered to be gloeocystidia. However, since these structures occur almost exclusively among the basidia rather than in the subhymenium, their designation as cystidioles seems more appropriate.

The data on the jacket of *Bourd. 7349* are identical to those given at the time the species was originally described. In addition, a later notation made on the jacket by Bourdot in 1920 indicated that this species had not been collected again. Therefore, *Bourd. 7349* is herein designated lectotype.

5. XENASMA PRUINOSUM (Pat.) Donk, Fungus **27**: 25. 1957; M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 103. *fig. 90*. 1960. FIG. 5

Corticium pruinosum Pat., Cat. Rais. Pl. Cell. Tunisie p. 60. 1897 (!!); Sacc. & Syd., Syll. Fung. **14**: 222. 1899.

Peniophora chordalis Höhn. & Litsch., Sitzungsb. K. Akad. Wiss. Wien Math.-Nat. Kl. **115** (Abt. I): 1598. *fig. 4*. 1906 (!!); Wiesner-Festschr. p. 71. 1908; Bourd. & Galz., Bull. Soc. Myc. Fr. **28**: 382. [1913]); Hym. Fr. p. 280. 1928; Litsch., in Pilat & Lindtner, Bull. Soc. Sci. Skoplje Sect. Sci. Nat. **18**: 184. 1938; Österr. Bot. Zeits. **88**: 115. 1939.

Peniophora subgelatinosa Litsch., Österr. Bot. Zeits. **77**: 128. 1928. *Peniophora pruinosa* (Pat.) Jackson, Can. Jour. Res. **28**(C): 530. *fig. 2.* 1950 (!!); J. Boidin, Rev. de Mycologie, Mémoire hors-série **6**: 118. *fig. 33.* 1956; A. Slysh, Syracuse Univ. Tech. Publ. **#83**: 22. *fig. 8.* 1960.

Fructification, effused, thin, in section 30–45 μ thick, grayish, when fresh cartilaginous-gelatinous, drying to a bluish-gray to gray vernicose film, under a lens the surface appearing pruinose, closely adnate; hyphae parallel to the substratum, nodose-septate, 2–3 μ in diam, conglutinate or the walls becoming gelatinized; cystidia cylindrical or slightly subulate, the walls thin above, thickened below, the base often bifurcate, 60–100 × 4–7(–9.5) μ; cystidioles sparse, often devoid of cytoplasm and only the partially collapsed walls remaining, cylindrical or somewhat subulate, simple, capitate, or with three to five blunt lobes, 20–60 × 2.5–3.5 μ; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, often obscure, 15–25 × 6–8 μ, bearing (4–)5–6(–7) short sterigmata 3–3.5 μ long; basidiospores hyaline, the wall minutely asperulate, the asperulations evident in Melzer's solution, disappearing in KOH or NH_4OH, nonamyloid, ellipsoid, laterally depressed, 5–7 × 3–4 μ.

On decayed wood and bark of *Fagus sylvatica, Platanus occidentalis, Populus, Quercus, Salix caprea,* and conifer (*Pinus?*). Known from Brazil, Austria, Denmark, France, Yugoslavia, South Africa, Tunisia, and New York.

Specimens examined: Austria: *V. Litsch. 27* (as *P. pruinosa;* TRTC); in der Grossen Klause bei Aspang, Nieder-Österreich, Wechsel, 2.VI.1906 (TYPE of *P. chordalis;* FH).

Tunisia: El Fedja, I.1893, *N. Patouillard* (TYPE of *C. pruinosum;* FH).

New York: King's Ravine, N. of Frontenac Point, W. side Cayuga Lake, 8.VIII.1937, *H. S. Jackson* (TRTC).

6. XENASMA PRAETERITUM (Jackson) Donk, Fungus **27**: 25. 1957. FIG. 6

Peniophora praeterita Jackson, Can. Jour. Res. **28**(C): 533. *fig. 4.* 1950 (!!); A. Slysh, Syracuse Univ. Tech. Publ. **#83**: 21. *fig. 6.* 1960.

Fructification effused, thin, in section 20–30 μ thick, when fresh hyaline or bluish-gray, cartilaginous-gelatinous, drying to a whitish vernicose film, under a lens the surface appearing pruinose, closely adnate; hyphae parallel to the substratum, nodose-septate, 1.5–2.5 μ in

diam, conglutinate or the walls becoming gelatinized; cystidia numerous, subcylindrical, somewhat flexuous, thin-walled, the base often bifurcate, 48–92 × 6–11 μ; cystidioles few, cylindrical or capitate, the base often bifurcate, 12–25 × 3–5 μ, the apical bulb 4–5 μ in diam; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 18–25 × 6–8.5 μ, bearing three to five divergent, subulate sterigmata, 4.5–5 × 1.5 μ; basidiospores hyaline, the wall prominently asperulate, nonamyloid, broadly ellipsoid to subglobose, 5.5–9 × 4.5–7.5 μ.

On decayed deciduous wood and bark—*Acer, Betula, Populus, Salix,* and *Ulmus americana.* Known from Ontario, Connecticut, and Illinois.

Specimens examined: Ontario: *R. F. Cain* (TRTC 13713, 13714, 13715, 13716, 15126, 15184, 17595, 17596, 17597 TYPE, 17598, 17599).

Illinois: Brownfield Woods, Urbana, 6.VIII.1960, *A. E. Liberta 202* (ILL; TRTC); 19.IX.1960, *A. E. L. 203, 205* (ILL; TRTC).

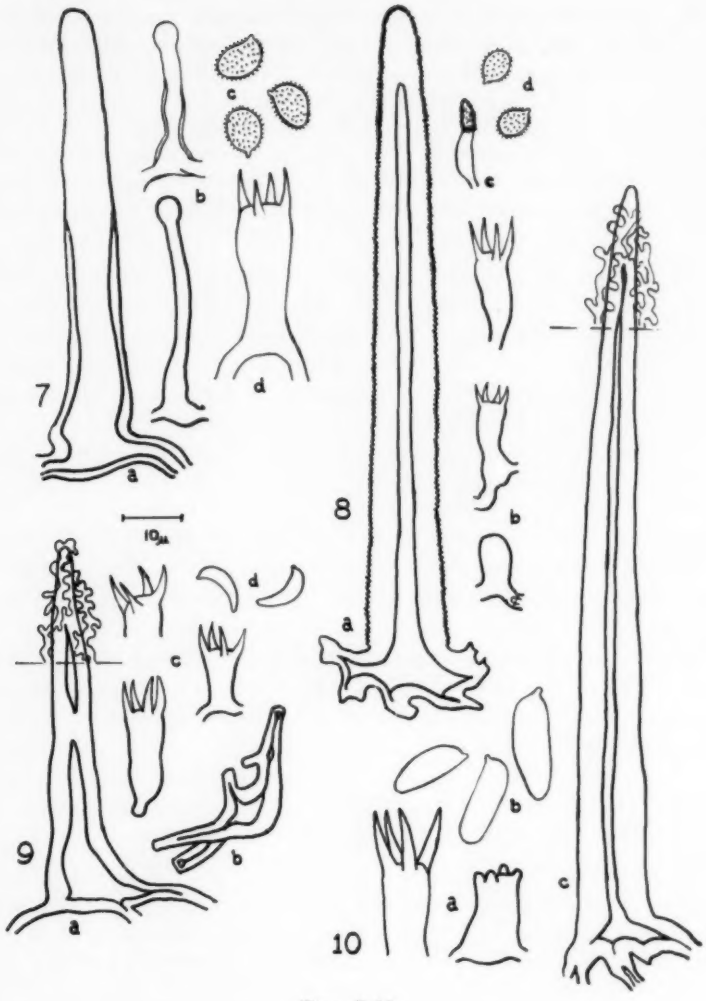
This species is easily distinguished by its thin-walled cystidia and asperulate spores which do not become smooth in KOH or NH_4OH.

7. XENASMA RIMICOLA (Karst.) Donk, Fungus **27**: 26. 1957. FIG. 7

Corticium rimicolum Karst., Hedwigia **35**: 45. 1896 (!); Bidr. Känned Finl. Nat. Folk **62**: 93. 1903; Sacc. & Syd., Syll. Fung. **14**: 221. 1899.

Peniophora rimicola (Karst.) Höhn. Litsch., Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. **115** (Abt. I): 1556. 1906 (!); Bourd. & Galz., Hym. Fr. p. 281. 1928; Rogers, Univ. Iowa Studies Nat. Hist. **17**: 31. *fig. 16.* 1935; Jackson, Can. Jour. Res. **28**(C): 527. *fig. 1.* 1950; Cunningham, Trans. Roy. Soc. New Zealand **83**: 288. *fig. 21.* 1955; A. Slysh, Syracuse Univ. Tech. Publ. #**83**: 22. *fig. 7.* 1960.

Fructification, effused, thin, in section 20–50 μ thick, when fresh hyaline or bluish-gray, sometimes yellowish in older portions, cartilaginous-gelatinous, drying to a whitish gray semitransparent vernicose film, under a lens the surface appearing pruinose, sometimes with fertile strands extending over the surface or at the margins, closely adnate; hyphae parallel to the substratum, nodose-septate, 1.5–2.5 μ in diam, conglutinate or the walls becoming gelatinized; cystidia cylindrical to slightly subulate, the base often bifurcate, walls thin above, thickened below, 50–125 × 10–15 μ, the thickened portions remaining as tubules in old collections; cystidioles cylindrical or subclavate, simple or capitate, 24–37 × 2.5–3.5 μ, the bulb at the apex 3–5 μ in diam; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 15–24(–29.5) × 7–8 μ, bearing two



FIGS. 7–10.

FIG. 7. *Xenasma rimicola,* a: cystidium, b: cystidioles, c: spores, d: basidium, from type of *Corticium rimicolum.* FIG. 8. *X. clematidis,* a: cystidium, b: basidia, c: incrusted paraphysoid hypha, d: spores, from Galz. ex herb. Bres. FIG. 9. *X. Dussii,* a: cystidium with a portion of the hyphal sheath, b: cystidial base, c: basidia, d: spores, from type of *Peniophora vermicularis.* FIG. 10. *X. macrosporum,* a: basidia, b: spores, c: cystidium with a portion of the hyphal sheath, from type.

to four short, arcuate sterigmata 3–4.5 × 1.5 μ; basidiospores hyaline, the wall finely asperulate, the asperulations evident in Melzer's solution, disappearing in KOH or NH_4OH, broadly ellipsoid to obovate, slightly depressed on one side with a lateral apiculus, (6.5–)8.5–10.5 × (3.5–) 4.5–7 μ.

On *Fomes conchatus*, stems of *Rubus*, wood and bark of *Acer macrophyllum*, *Populus tremuloides*, *Quercus Garryana*, *Alnus*, *Fraxinus*, *Salix*, and *Ulmus*. Known from Finland, France, Sweden, Brazil, New Zealand, British Columbia, Ontario, Missouri, Oregon, and Washington.

Specimens examined: Finland: Mustalia, *P. Karsten* (as *C. rimicolum*; FH).

Brazil: Sao Leopoldo, IX.1932, *J. Rick* (as *Tulasnella metallica* Rick; MO 71742, in herb. D. P. Rogers).

Ontario: *H. S. Jackson* (TRTC 12499, 18213, 19121, 20554, 20667).

Missouri: *A. M. Rogers 818, 819.*

Oregon: *A. M. & D. P. Rogers 731, 817.*

The texture and cystidia of this species are very similar to the texture and cystidia of *Xenasma pruinosum*. However, the cystidioles of *X. rimicola* are simple or capitate in contrast to the lobed cystidioles of *X. pruinosum*, and the spores of the former are larger than those of the latter. In addition, the basidia of *X. rimicola* bear two to four sterigmata while those of *X. pruinosum* bear four to seven sterigmata.

8. **Xenasma clematidis** (Bourd. & Galz.) Liberta, comb. nov. FIG. 8

Peniophora clematitis (sic) Bourd. & Galz., Bull. Soc. Myc. Fr. **28**: 383. [1913]; Hym. Fr. p. 286. *fig. 84.* 1928 (!); J. Boidin, Ann. Univ. Lyon Sci. Nat. **10**(C): 29. *fig. 1.* 1958; as *P. clematidis*, Sacc., Syll. Fung. **23**: 535. 1925; Jackson, Can. Jour. Res. **28**(C): 716. 1950.

Peniophora abietis Bourd. & Galz. (as "subsp." under *P. aegerita* Höhn. & Litsch.), Bull. Soc. Myc. Fr. **28**: 383. [1913]; Sacc., Syll. Fung. **23**: 535. 1925; as species, Bourd. & Galz., Hym. Fr. p. 286. 1928; J. Eriks., Sv. Bot. Tidskr. **48**: 193. 1954; Donk, Fungus **26**: 15. 1956; M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 136. *fig. 128.* 1960; A. Slysh, Syracuse Univ. Tech. Publ. #**83**: 56. *fig. 48.* 1960.

Peniophora gladiola Cunn., Trans. Roy. Soc. New Zealand **83**: 283. *fig. 22.* 1956 (!).

Fructification effused or maculiform, thin, in section 30–50 μ thick, grayish-white, porous or closely reticulate, hispid, adherent; hyphae mostly parallel to the substratum, nodose-septate, 1.5–3 μ in diam, con-

glutinate and often surrounded by acicular crystals, or the walls becoming gelatinized; cystidia conical, perpendicular to the horizontal hyphae, the base several-rooted, the walls thick, lamellate, the outer layer roughened, the inner layer strongly pseudoamyloid in Melzer's solution, 75–225 × (6.5–)10–17 μ; paraphysoid hyphae with caps of acicular crystals often abundant in the hymenium, arising as perpendicular branches of the horizontal hyphae; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate or several-rooted, often obscure, or occasionally terminal on short upright hyphae and subtended by a clamp, 10–26 × (4.5–)5–9 μ, bearing two to four stout sterigmata 6.5–9 × 1.5–2.5 μ; basidiospores hyaline, the wall asperulate, nonamyloid, globose to obovate, (4–)5–9 × (4–)4.5–7.5 μ.

On decayed wood of *Clematis Vitalba,* bark of *Hedycarya arborea, Brachyglottis repanda, Weinmannia racemosa,* and conifer—*Tsuga.* Known from Denmark, France, New Zealand, Ontario, and New York.

Specimens examined: France: Aveyron, Galz. (ex Bres. ex orig. exs.; NY; TRTC).

Ontario: *R. F. Cain* (TRTC 16312); *H. S. Jackson* (TRTC 17593), both as *P. abietis.*

New Zealand: *J. M. Dingley* (as *P. gladiola;* N.Z.P.D.D. herb. no. 11444; TRTC).

This species has been critically studied and discussed by L. K. Weresub (**1957**) and J. Boidin (**1958**). Weresub suggested that it might be related to such taxa as *Corticium insperatum* Jackson and *C. pseudotsugae* Burt. Both of these species have already been transferred to *Xenasma,* the former by Donk (**1957**) and the latter by J. Eriksson (**1958**).

X. clematidis is easily recognized by its long, thick-walled cystidia with a roughened outer wall, asperulate spores, and paraphysoid hyphae which are capped with acicular crystals.

Weresub's proposed synonymy has been accepted in this analysis.

9. **Xenasma Dussii** (Pat.) Liberta, comb. nov. FIG. 9

Hypochnus Dussii Pat., Bull. Soc. Myc. Fr. **15**: 202. 1899; Sacc., Syll. Fung. **16**: 197. 1902.

Epithele Dussii (Pat.) Pat., Essai tax. p. 59. 1900 (!!); Duss, Fl. Crypt. Ant. Fr. p. 226. 1903; Burt, Ann. Missouri Bot. Gard. **6**: 265. 1920.

Peniophora Dussii (Pat.) Höhn. & Litsch., Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. **116**: 749. *fig. 2.* 1907.

Peniophora vermicularis Wakef., Kew Roy. Bot. Gard. Bull. **1915**: 371. *fig.* v. 1915 (!!); Sacc., Syll. Fung. **23**: 540. 1925; G. H. Cunningham, Trans. Roy. Soc. New Zealand **83**: 287. *fig. 25.* 1955.

Fructification maculiform, thin, in section 25–35 μ thick, white, forming a thin film over the substratum, under a lens appearing pruinose and prominently hispid, easily separable; hyphae mostly parallel to the substratum, nodose-septate, 2–2.5 μ in diam, conglutinate or the walls becoming gelatinized; cystidia conical, perpendicular to the horizontal hyphae, the base several-rooted, the walls thick, lamellate, the outer layer coated with scattered crystals or more often sheathed by delicate dendritic hyphae about 1 μ in diam, 55–100 × 8.5–15 μ; basidia cylindrical to subclavate, somewhat sinuate, borne directly on the horizontal hyphae. The base bifurcate, often obscure, or terminal on short upright hyphae and subtended by a clamp, 12.5–17 × 5–6 μ, bearing four arched sterigmata, 3.5–5 × 1.5 μ; basidiospores hyaline, the wall smooth, nonamyloid, lunate to falcate, 7.5–14 × 2.5–3.5 μ.

On dead stipes of tree ferns—*Cyathea medullaris, Hemitelia smithii,* and *Alsophila aspera.* Known from Colombia, Guadeloupe, and New Zealand.

Specimens examined: Colombia: *G. W. Martin 3657* (as *P. Dussii;* IA; DAOM 72146).

Guadeloupe: Tannes, 1899, *C. Duss* (Pat. 3, TYPE of *E. Dussii;* NY; FH).

New Zealand: Whakarewarewa, 1914, *W. N. Cheesman* (TYPE of *P. vermicularis;* K).

This species is easily recognized by its conical, thick-walled cystidia that are sheathed in dendritic hyphae, and lunate to falcate spores.

The synonymy proposed by Weresub (**1957**) has been confirmed in the present study. The method of basidial development, the rooted base of the cystidia, and the conglutinate or gelatinized condition of the hyphae indicate the close affinity of this species with other members of *Xenasma.*

10. **Xenasma macrosporum** Liberta, sp. nov. FIG. 10

Fructificatio effusa, tenuissima, in sectione 30–50 μ crassa, alutacea, cereo-pruinosa, sub lente hispida; hyphae haud clarae, glutinosae, substrato parallelae, nodose-septatae, 1.5–2 μ diam; cystidia conica, basi multo-radicosa, tunica crassa, lamellata, extus a hyphis dendriticis circumtexta, c. 1 μ diam, lamina interiore ad basim pseudoamyloidea, 125–164 × 9.5–22.5 μ; basidia cylindracea vel subclavata, basi biradicosa, haud clara, interdum terminalia et haud radicosa ansa subtenta,

16.5–22.5 × 5–9.5 μ; sterigmata 4, crassa, 9–11 × 2 μ gerentia; basidiosporae hyalinae, tunica tenui, levi, haud amyloidea indutae, oblongo-cylindraceae, oblongo-ellipsoideae, vel late subnaviculares, 12–19 × 4.5–7 μ.

Fructification effused, thin, in section 30–50 μ thick, Cartridge Buff to Cream Color, waxy-pruinose, under a lens appearing hispid, adnate; hyphae mostly parallel to the substratum, nodose-septate, 1.5–2 μ in diam, conglutinate or the walls becoming gelatinized; cystidia conical, perpendicular to the horizontal hyphae, the base several-rooted, the walls thick, lamellate, externally sheathed by delicate dendritic hyphae approximately 1 μ in diam, the inner lamella strongly pseudoamyloid in Melzer's solution, especially near the rooted base, 125–164 × 9.5–22.5 μ; basidia cylindrical or subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, or less often terminal on short upright hyphae and subtended by a clamp, 16.5–22.5 × 7–9.5 μ, bearing four stout sterigmata 9–11 × 2 μ; basidiospores hyaline, the wall thin, smooth, nonamyloid, oblong-cylindrical or oblong-ellipsoid to occasionally subnavicular, 12–19 × 4.5–7 μ.

On decayed wood. Known from Panama.

Specimen examined: Panama: Prov. Chiriqui: Valley of upper Rio Chiriqui Viejo, 1600–1800 m, 28.VI.1935, *G. W. Martin 2097* (IA; D. P. Rogers; A. E. Liberta), TYPE.

Although the description of this species is based upon a single collection, the size and morphology of the spores readily distinguish it from previously described species having thick-walled cystidia sheathed in dendritic hyphae. Its affinities appear to lie in *Xenasma* for the same reasons as cited under *X. Dussii*.

11. **Xenasma vermiferum** (Bourd.) Liberta, comb. nov. FIG. 11

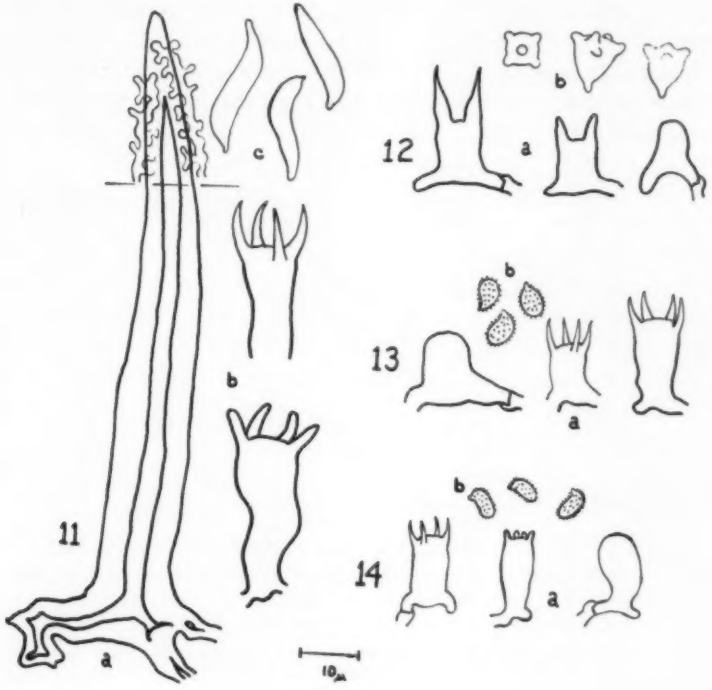
Peniophora vermifera Bourd., Rev. Sci. Bourb. **23**: 13. 1910 (p. 11 of repr., 1910) (!); Sacc., Syll. Fung. **21**: 408. 1912; Bourd. & Galz., Bull. Soc. Myc. Fr. **28**: 384. [1913]; Hym. Fr. p. 285. 1928; Weresub, Can. Jour. Bot. **31**: 773. *fig. 9.* 1953; G. H. Cunningham, Trans. Roy. Soc. New Zealand **83**: 286. *fig. 24.* 1955; Donk, Fungus **26**: 14. 1956.

Peniophora subglebulosa Höhn. & Litsch., Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. **116**: 823. *fig. 10.* 1907; Sacc., Syll. Fung. **21**: 408. 1912; Bourd. & Galz., Hym. Fr. p. 286. 1928 (fide Weresub, p. 143, 1957).

Tubulicrinis vermifera (Bourd.) M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 136. *fig. 127.* 1960.

Fructification effused or maculiform, in section up to 200 μ thick,

white or cream to Buff Yellow, arid crustaceous, smooth or cracked, under a lens the surface appearing densely hispid, adherent; hyphae mostly parallel to the substratum, nodose-septate, 1.5–2.5 μ in diam, conglutinate or the walls becoming gelatinized; cystidia conical, perpendicular to the horizontal hyphae, the base several-rooted, the walls thick, lamellate, externally covered with a roughened crystalline shell or more



FIGS. 11–14.

FIG. 11. *Xenasma vermiferum,* a: cystidium with a portion of the hyphal sheath, b: basidia, c: spores, from Galz. 1911 ex herb. Bres. FIG. 12. *X. ludibundum,* a: basidia, b: spores, from type. FIG. 13. *X. tulasnelloideum,* a: basidia, b: spores, from V. Litsch. 12.VII.1927. FIG. 14. *X. insperatum,* a: basidia, b: spores, from type.

often sheathed by dendritic hyphae approximately 1 μ in diam, 75–185 $\times$ 10–25 μ; basidia sinuately cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, often obscure, or occasionally terminal on short upright hyphae and subtended by a clamp, 20–45 $\times$ (5–)8.5–11.5 μ, bearing four divergent, arcuate sterigmata 6.5–7.5

(–10.5) × 2.5 μ; basidiospores hyaline, the wall smooth, nonamyloid, flexuous navicular, pointed at both apices, but broader at the apiculate end, (10–)15–25(–30) × (3–)4–5.5 μ.

On stems and decayed wood or bark of *Dysoxylum spectabile, Erica arborea, E. cinerea, Gaultheria shallon, Metrosideros lucida, Olearia furfuracea, Pseudopanax crassifolium, Salix cinerea, Senecio rotundifolius,* and *Vitex lucens.* Known from Corsica, Denmark, France, New Zealand, British Columbia, Hawaii, and California.

Specimens examined: France: 1911, *Galz.* (ex Bres.; K).

New Zealand: *S. D. Baker* (N.Z. P.D.D. herb. no. 13737; TRTC).

California: *H. E. Parks 4028* (TRTC).

Hawaii: *D. P. Rogers 1961* (TRTC; BISH).

Christiansen (**1960**) recently transferred this species to the genus *Tubulicrinis* Donk, but Weresub's (**1957**) critical analysis of section *Tubuliferae* of the genus *Peniophora* led her to report that *Peniophora vermifera* was excluded from *Tubulicrinis,* as delimited by her, because it possessed intertwined, mainly horizontal hyphae, sheathed cystidia with a multi-rooted base, and basidia intimately connected with the hyphae. The present analysis has confirmed her report, and on the basis of the characters enumerated above, *P. vermifera* has been herein transferred to *Xenasma.*

12. **Xenasma ludibundum** Rogers & Liberta, sp. nov. FIG. 12

Fructificatio effusa, tenuissima, in sectione 20–30 μ crassa, alba, haud conspicua, sub lente pruinosa vel tenuiter cereo-crustosa; hyphae haud clarae, glutinosae, substrato parallelae, nodoso-septatae, 1.5–3 μ diam; basidia cylindracea vel subclavata, basi biradicosa, haud clara, 6.5–10.5 × 6.5–7 μ, sterigmata 2 crassa, 7–10.5 × 2.25(–3) μ gerentia; basidiosporae hyalinae, tunica tenui, haud amyloidea indutae, turbinatae, tuberculis una apicali atque quattuor in margine faciei superioris insidentibus ornatae, basi prominenter apiculatae, 5–9 × 4.5–8 μ.

Fructification effused, thin, in section 20–30 μ thick, white, forming an inconspicuous film over the substratum, under a lens appearing pruinose to thinly ceraceous-crustaceous, closely adnate; hyphae parallel to the substratum, nodose-septate, 1.5–3 μ in diam, conglutinate or the walls becoming gelatinized; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, 6.5–10.5 × 6.5–7 μ, bearing two stout sterigmata 7–10.5 × 2–2.5(–3) μ; basidiospores hyaline, nonamyloid, turbinate with one central and four diagonally arranged tubercles about the periphery of the apex, prominently apiculate at the base, 5–9 × 4.5–8 μ.

On bark of *Quercus* and decayed wood of *Chamaecyparis thyoides*. Known from Massachusetts, Oregon, and Rhode Island.

Specimens examined: Massachusetts: Blue Hill, 31.XI.1935, *D. P. Rogers 4* (FH; TRTC; A. E. Liberta), TYPE.

Oregon: Reedsport, 22.X.1938, *A. M. & D. P. Rogers 973*.

Rhode Island: Exeter, 4.XI.1941, *A. M. & D. P. R. 949*.

X. ludibundum can be immediately recognized by its unique spores and basidia which bear only two large sterigmata. The conglutinate or gelatinized hyphae, the manner of basidial development, and the basidial morphology indicate that the affinities of this species lie in the genus *Xenasma*.

13. XENASMA TULASNELLOIDEUM (Höhn. & Litsch.) Donk, Fungus **27**: 26. 1957; M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 105. *fig. 92*. 1960. FIG. 13

Corticium tulasnelloideum Höhn. & Litsch., Sitzungsber. K. Akad. Wiss. Wien Math.-Nat. Kl. **117** (Abt. I): 1118. *fig. 10*. 1908 (!); Wakef. & Pears., Trans. Brit. Myc. Soc. **8**: 217. 1923; Bourd. & Galz., Hym. Fr. p. 235. 1928; Rogers, Univ. Iowa Studies Nat. Hist. **15**(3): 20. *fig. 27*. 1933; Litsch., in Pilat & Lindtner, Bull. Soc. Sci. Skoplje Sect. Sci. Nat. **18**: 177. 1938; Österr. Bot. Zeits. **88**: 114. 1939; Rogers & Jackson, Farlowia **1**: 292. 1943; G. H. Cunningham, Trans. Roy. Soc. New Zealand **82**: 300. *fig. 16, 16b*. 1954.

Corticium incanum Burt, Ann. Missouri Bot. Gard. **13**: 205. 1926.

Hypochnus tulasnelloideum (Höhn. & Litsch.) Rea, Trans. Brit. Myc. Soc. **12**: 222. 1927.

Tomentella tulasnelloidea (Höhn. & Litsch.) Skovsted, Compt. Rend. Travaux Lab. Carlsberg Ser. Physiol. **25**(1): 14. *fig. 7*. 1950.

Fructification effused, thin, in section 20–60 μ thick, Pallid Mouse Grey or Pale Smoke Grey to Warm Buff, forming a ceraceous film over the substratum or when thicker glaucous or chalky to arid-crustaceous, under a lens appearing waxy-pruinose or minutely porous-reticulate to occasionally raduloid, closely adnate; hyphae mostly parallel to the substratum, nodose-septate, (1–)1.5–2.5 μ in diam, conglutinate or the walls becoming gelatinized; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, often indistinct, 9–17(–20) × 5–8 μ, bearing four subulate sterigmata (3–)3.5–6(–9) μ long; basidiospores hyaline, the wall finely asperulate, nonamyloid, globose or subglobose to obovate and abruptly laterally attenuated at the base, 3.5–6 × 3–6 μ.

On *Acacia Koa, Agathis australis, Beilschmiedia tawa, Carpinus betulus, Corylus avellana, Dacrydium cupressinum, Fagus grandifolia, F. sylvatica, Fuchsia excorticata, Nothopanax aboreum, Populus tremuloides, Tilia americana, Wintera colorata, Acer, Aleurites, Betula, Hamamelis, Metrosideros, Prunus, Oxylobium, Quercus, Salix, Ulmus,* and decayed coniferous wood and bark—*Pinus strobus* and *Cupressus macrocarpa.* Known from Austria, Denmark, England, France, Sweden, Yugoslavia, Hawaii, New Zealand, British Columbia, Ontario, Quebec, Colombia, Connecticut, Georgia, Iowa, Massachusetts, Missouri, New Jersey, New Hampshire, New York, Ohio, Oregon, and Rhode Island.

Specimens examined: all as *C. tulasnelloideum* unless otherwise cited.

Austria: Lainzer-tiergarten bei Wien, 12.VII.1927, *V. Litsch.* (IA).

Hawaii: *D. P. Rogers 663, 1946, 3184, 3185, 3187; I. A. Abbot & R. Kuykendall* (D.P.R. 662; BISH).

Ontario: *H. S. Jackson* (TRTC 9297); *R. F. Cain* (TRTC 13758).

Colombia: Magdalena: *G. W. Martin 3244* (IA), *3585* (IA).

Iowa: *D. P. Rogers 78* (OSC), *256* (IA; W), *348* (IA, K), *1321* (NY; OC; TRTC; UPS), *3891, 3894* (FH), *3895, 3896* (IA), *3897, 3898, 3899, 3900, 3901, 3902; A. M. & D. P. Rogers 3890;* Iowa City, 6.X.1932, *G. W. Martin* (D.P.R.); Esterville, 15.VII.1932, *H. C. Gilbert* (D.P.R.).

Massachusetts: Blue Hill, Canton, 29.V.1936, *A. M. & D. P. R.* (FH); Waltham, 4.VIII.1936, *G. D. Darker* (D.P.R.); Sharon, 14.XI. 1936, *A. P. D. Piguet* (FH; D.P.R.); Springfield, 18.VIII.1943, *D. P. R. 3908;* Forest Park, Springfield, 19.VIII.1943, *A. M. & D. P. R.;* Great Cedar Swamp, Milton, 15.VII.1942, *A. M. & D. P. R. 3877, 3878, 3879.*

Missouri: *A. M. L. Rogers* (D.P.R. 3909).

New Hampshire: Pequaket, on Piper Trail, 25–26.VII.1941, *D. H. Linder & R. Singer* (FH).

New York: *A. M. & D. P. R. 3880, 3881* (FH).

Ohio: *D. P. R. 3882, 3883, 3884, 3885, 3886, 3887, 3888, 3889.*

Oregon: *D. P. R. 1076* (OSU).

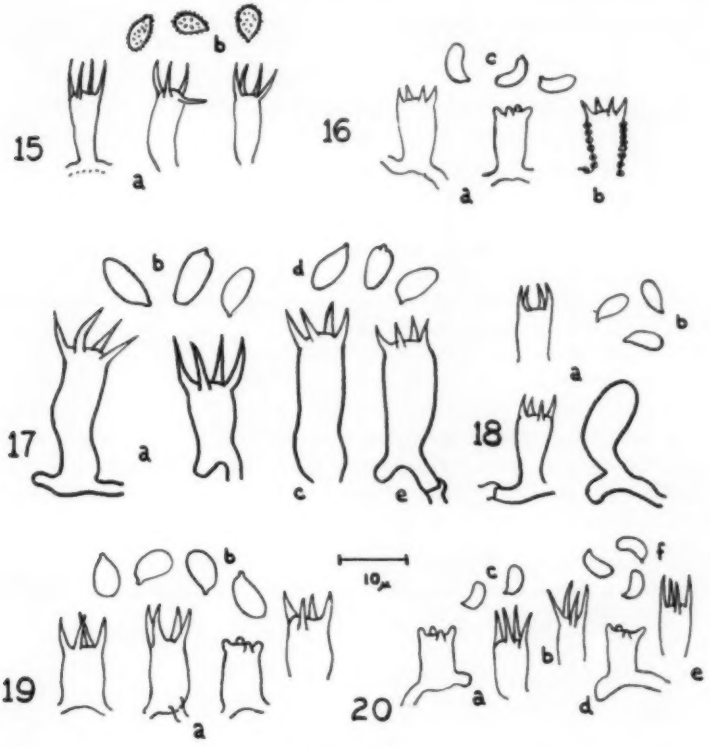
Rhode Island: *D. P. R. 3910; A. M. & D. P. R. 3911, 3912, 3913.*

This species appears to have a wide distribution. It is easily recognized by its finely asperulate spores which are mostly globose or subglobose in contrast to the ellipsoid spores of *Xenasma insperatum* (Jackson) Donk or ovoid-ellipsoid spores of *X. tenuiculum* (Litsch.) J. Eriks.

14. XENASMA INSPERATUM (Jackson) Donk, Fungus **27**: 25. 1957. FIG. 14

Corticium insperatum Jackson, Can. Jour. Res. **28**(C): 718. *fig. 2.* 1950 (!!).

Fructification effused, thin, in section 30–45 μ thick, gray to bluish-gray, subceraceous to ceraceous-pruinose, adnate; subiculum meager,



FIGS. 15–20.

FIG. 15. *Xenasma tenuiculum,* a: basidia, b: spores, from type. FIG. 16. *X. Lloydii,* a: basidia, b. basidium with a few incrusting granules, c: spores, from type. FIG. 17. *X. filicinum,* a: basidia, b: spores, from Bourd. 7493; c: basidium, d: spores, from D. P. Rogers 3561; e: basidium, from type of *Corticium pseudotsugae.* FIG. 18. *X. thymicola,* a: basidia, b: spores, from Bourd. 14189. FIG. 19. *X. subnitens,* a: basidia, b: spores, from type. FIG. 20. *X. grisellum,* a, b: basidia, c: spores, from type of *Corticium grisellum;* d, e: basidia, from type of *C. pruina;* f: spores, from Eriks. 3320.

composed of horizontal hyphae which are nodose-septate, 1–2.5 μ in diam, conglutinate or the walls becoming gelatinized, the subhymenium of compact nodulose hyphae 1.5–2.5 μ in diam; basidia cylindrical to subclavate, the base very often bifurcate, 8.5–13(–15) × 4.5–6 μ, bearing four short sterigmata 1.5–3.5 μ long; basidiospores hyaline, the wall closely and finely asperulate, nonamyloid, ellipsoid and laterally depressed, 4–4.5 × 2–2.5 μ.

On bark of deciduous branches. Known from Ontario.

Specimen examined: Ontario: *C. G. Lloyd* (BPI 16008; TRTC), TYPE.

15. XENASMA TENUICULUM (Litsch.) J. Eriks., Symb. Bot. Upsal. **16**(1): 66. 1958. FIG. 15

Corticium tenuiculum Litsch., Ann. Mycol. **39**: 130. *fig. 9.* 1941 (!!).

Fructification irregularly effused, thin, in section 15–30 μ thick, when fresh subhyaline, ceraceous, drying whitish, crustaceous, the margin thinning, under a lens appearing subpruinose, closely adnate; hyphae parallel to the substratum, nodose-septate, 1–2 μ in diam, conglutinate or the walls becoming gelatinized, scattered crystals often present; basidia subcylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 9.5–13.5 × 3.5–4.5 μ, bearing four long, slender sterigmata 3.5–7.5(–8) μ long; basidiospores hyaline, the wall densely and minutely asperulate, nonamyloid, ellipsoid or ovoid, occasionally slightly depressed laterally, the base obliquely subacute, 4–5 × 2.5–3 μ.

On decayed wood of *Fagus*. Known from Sweden.

Specimen examined: Sweden: Småland: Lidhult parish, Gåshult, 15.XII.1910, *L. Romell 3461*, TYPE.

16. **Xenasma Lloydii** Liberta, nom. nov. FIG. 16

Corticium Lloydii Bourd. & Galz., Hym. Fr. p. 210. *fig. 65.* 1928 (!!) (not *C. Lloydii* Bres., 1926).

Fructification effused, thin, in section 20–30 μ thick, Light Brownish Olive, vernicose-crustose, under a lens appearing pruinose, closely adnate; hyphae parallel to the substratum, nodose-septate, 1.5–3.5 μ in diam, conglutinate or the walls becoming gelatinized; basidia surrounded by minute olivaceous granules which give the fructification its color, cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 9–12 × 4.5–6 μ, bearing four short sterigmata 2.5–3 μ long; basidiospores hyaline, the wall smooth, non-

amyloid, oblong-ellipsoid and laterally depressed to suballantoid, 5.5–7 × 2.5–3 μ.

On *Pinus* sp. and *Pinus Banksiana*. Known from Sweden and Ontario.

Specimens examined: Sweden: Bygget, 1909, *C. G. Lloyd 09131* (BPI 5211; Bourd. 13776; PC), TYPE.

Ontario: *H. S. Jackson* (TRTC 14621).

This species was placed in section *Athele* by Bourdot & Galzin (**1928**), and was considered to be one of the more typical members of that section by Jackson (**1950b**).

Notations made by Lloyd on the jackets of both the BPI and PC specimens indicate that they are portions of the same collection. Additional notations made by Bourdot indicate that he saw the entire collection.

Bourdot & Galzin described and illustrated the spores of *C. Lloydii* as "oblong-subcylindric, occasionally attenuated at the base, 5–6 × 2.5–3 μ, hyaline, with two deep green polar granules." The structures described as spores, without the aid of an oil immersion lens, are in reality unicellular algae. Although basidiospores are sparse in the type material, a sufficient number was seen to allow their redescription. Therefore, the fungus material of the Lloyd collection, which has been redescribed in the formal description, is designated the type of *Xenasma Lloydii*.

17. XENASMA FILICINUM (Bourd.) M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 106. *fig. 94.* 1960. FIG. 17

Corticium filicinum Bourd., Rev. Sci. Bourb. **23**: 12. 1910 (p. 10 of repr., 1910) (!!); Bourd. & Galz., Bull. Soc. Myc. Fr. **27**: 250. 1911; Hym. Fr. p. 209. *fig. 64.* 1928; G. H. Cunningham, Trans. Roy. Soc. New Zealand **82**: 307. *fig. 23.* 1954.

Corticium pseudotsugae Burt, Ann. Missouri Bot. Gard. **13**: 246. 1926 (!!).

Corticium asserophilum Litsch., Ann. Mycol. **32**: 55. *fig. 2a, b.* 1934 (!).

Xenasma pseudotsugae (Burt) J. Eriks., Symb. Bot. Upsal. **16**(1): 65. 1958 (!); M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 107. *fig. 95.* 1960.

Fructification effused or maculiform, thin to rather thick, in section up to 400 μ thick, when fresh Smoke Gray to Glaucous-Gray, drying white or Light Buff to Warm Buff, glaucous or chalky to ceraceous-

crustaceous, smooth or deeply cracked when thick, under a lens appearing as an evenly pruinose surface overlying a vernicose crust, closely adnate; hyphae mostly parallel to the substratum, nodose-septate, 1.5–3.5(–5) μ in diam, conglutinate or the walls becoming gelatinized; basidia cylindrical to subclavate, borne directly on the horizontal hyphae or on short upright hyphae, the base bifurcate, very often obscure, 11–26 × 5–7.5(–8) μ, bearing four straight, slender sterigmata 2.5–6(–8) μ long; basidiospores hyaline, often pluriguttulate, the wall smooth, nonamyloid, obovate or broadly ellipsoid to narrowly or broadly subellipsoid-navicular, i.e., rather broad near the middle and tapering toward the apex and abruptly, laterally toward the apiculus, 5–10.5 × 3–5 μ.

On stems of *Athyrium filix-foemina, Blechnum fraseri, Cyathea dealbata, Hemitelia smithii, Polystichum* (*Dryopteris*) *filix-mas, Pteridium aquilinum, P. esculentum,* and decayed wood of *Pinus rigida, P. strobus, Pseudotsuga taxifolia, Thuja plicata, Tilia americana,* and *Quercus.* Known from Austria, Denmark, France, Sweden, New Zealand, British Columbia, Ontario, Idaho, Massachusetts, New York, Oregon, Pennsylvania, and Rhode Island.

Specimens examined: all as *C. filicinum* unless otherwise cited.

Austria: Tirol, Klosterberg bei Innsbruck, 1.IV.1926, *V. Litsch.* (as *C. asserophilum;* TRTC).

France: Château Charles, Allier, 20.VII.1909, *Bourd. 6810* (PC), LECTOTYPE; Marais de Frégèfont, Tarn, 27.VI.1910, *Galz. 6428* (Bourd. 7453; PC); Le Rec, près St. Sernin, Aveyron, 28.VIII.1911, *Galz. 9917* (Bourd. 18070; K); Massalas, Aveyron, 20.X.1911, *Galz. 9965* (Bourd. 29717; PC).

Sweden: Småland: Varnamo, between Björs and Wörningsnäs, 14.VIII.1959, *J. Eriks.; J. Eriks. 8357* (both as *X. pseudotsugae*).

British Columbia: *I. Mounce F6512* (TRTC).

Ontario: TRTC 12927; *H. S. Jackson* (TRTC 15156) (both as *C. asserophilum*).

Idaho: *E. E. Hubert* (J. R. Weir 11617; TRTC, FH) (TYPE of *C. pseudotsugae*).

Massachusetts: *D. P. Rogers 712; A. M. & D. P. R. 184, 185, 3918, 3920; D. H. Linder,* (D.P.R. 111; FH), (D.P.R. 3914; FH; OC; TRTC), (D.P.R. 3915; FH; OC; UPS; TRTC), (D.P.R. 3916; TRTC), (D.P.R. 3917; FH).

New York: *A. M. & D. P. R. 3921, 3922.*

Oregon: *A. M. & D. P. R. 385, 471, 586* (OSC; FH), *587, 588* (OSC), *589* (TRTC), *590, 591* (OSC), *592, 597* (OSC; TRTC), *599*

(OSC), *700, 709, 710, 2653, 2742, 2743, 2744, 2745, 2746, 2747, 2748, 2950, 3226, 3269, 3300, 3306, 3559, 3560, 3561, 3583, 3592, 3594, 3598, 3602, 3747, 3761* (all four digit numbers at ILL).

Pennsylvania: Pine Hall, Center Co., 1.VIII.1921, *L. O. Overholts & J. C. Donegon* (as *C. asserophilum;* TRTC ex Overholts).

The color and texture of the fructification, the size of the basidia, and the more or less navicular spores make it possible to recognize this species easily.

The American and European collections of *Corticium* (*Xenasma*) *pseudotsugae* on wood and bark agree in color, texture, and basidial morphology with the authentic European material of *C. filicinum* on fern. In the collections on wood and bark, the breadth of the spores is somewhat greater in proportion to the length than in the collections on fern, but the variation in this respect is too great, not only among various collections, but also within single collections, to permit satisfactory separation of *X. pseudotsugae* from *X. filicinum*. Therefore, *X. pseudotsugae* is herein reduced to synonymy.

On the jackets of the two specimens collected prior to or during the year in which *C. filicinum* was first described, sketches or measurements do not appear. Therefore, on the basis of its earlier date of collection, *Bourd. 6810* is designated lectotype.

18. **Xenasma thymicola** (Bourd. & Galz.) Liberta, comb. nov. FIG. 18

Corticium thymicolum Bourd. & Galz. (as "subsp." under *C. gemmiferum*), Hym. Fr. p. 211. 1928 (!).

Fructification effused, in section up to 200 μ thick, Pinkish-Buff to Cinnamon-Buff, arid-crustaceous, under a lens appearing pulverulent to pseudoporous, the surface often cracked, the margins thin, pruinose to vernicose, adnate; hyphae mostly parallel to the substratum, nodose-septate, 1–3 μ in diam, conglutinate and appearing slightly yellow in mass or the walls becoming gelatinized; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, 13–20 × 5–6 μ, bearing four slender sterigmata 3–4.5 μ long; basidiospores hyaline, the wall smooth, nonamyloid, obovate to oblong and abruptly attenuated at the base, 4.5–7 × 3–4 μ.

On stems of *Thymus*. Known from France.

Specimen examined: France: près Millau, Aveyron, 8.V.1911, *Galz. 8960, 9081* (Bourd. 14189; PC).

This species may be recognized by its texture and spores, the latter being larger than those of *Corticium grisellum* Bourd., and narrower than those of *C. subnitens* Bourd. & Galz.

Although Bourdot & Galzin (**1928**) originally published *C. thymicolum* in "slanted type" to indicate that it was to be considered a subspecies under *C. gemmiferum*, there appears to be no close relationship between these two taxa. Therefore, *C. thymicolum* is herein given specific rank and transferred to *Xenasma* on the basis of its basidial morphology, its manner of basidial development, and the conglutinate or gelatinized condition of the hyphae.

19. **Xenasma subnitens** (Bourd. & Galz.) Liberta, comb. nov. FIG. 19
Corticium subnitens Bourd. & Galz., Hym. Fr. p. 224. 1928 (!!).

Fructification effused, thin, in section 15–30 μ thick, when dry a nearly invisible bloom to a grayish-white vernicose film, under a lens appearing ceraceous-pruinose, occasionally finely cracked, closely adnate; hyphae parallel to the substratum, nodose-septate, (1–)2.5–4(–5) μ in diam, somewhat irregular, conglutinate or the walls becoming gelatinized; basidia short-cylindrical, borne directly on the horizontal hyphae, the base bifurcate, very often obscure, (8–)9.5–14 × (4.5–)5–7 μ, bearing four erect sterigmata 4–4.5 μ long; basidiospores hyaline, the wall smooth, nonamyloid, obovate to broadly oblong-ellipsoid, 5–7(–7.5) × 3.5–4.5(–5) μ.

On decayed wood of *Pinus, Pseudotsuga taxifolia,* and *Quercus.* Known from France, Iowa, and Oregon.

Specimens examined: France: Causse Noir, Aveyron, XI.1914, *Galz. 16600* (Bourd. 30464; PC), TYPE.

Iowa: Iowa City, 24.X.1931, *D. P. Rogers 3904.*

Oregon: N. Santiam road, N. of Detroit, 5.XI.1938, *A. M. & D. P. R. 598* (FH; OSC; TRTC).

This species is easily recognized by its texture and spore morphology.

Donk's (**1957**) suggestion that *Corticium subnitens* might be related to members of the genus *Xenasma* has been confirmed in the present study and the appropriate transfer made.

Bourdot & Galzin (**1928**) placed this species in group C of section *Ceracea* of *Corticium,* and reported the spores as obovate, 4–5 × 3–4 μ. Examination of the type revealed the presence of occasional oblong-ellipsoid as well as obovate spores, and a spore size that was larger than originally described. In addition, the basidia were found to be mostly short-cylindrical with a bifurcate base rather than obovate.

A sketch and measurements on the jacket of *Galz. 16600* coincide with the measurements given at the time of description. Also, the locale and substratum are identical to those originally reported. Therefore, *Galz. 16600* is herein considered type.

20. **Xenasma grisellum** (Bourd.) Liberta, comb. nov. FIG. 20

Corticium grisellum Bourd., Rev. Sci. Bourb. **1922**: 17. 1922 (p. 6 of repr., 1922) (!!); Bourd. & Galz., Hym. Fr. p. 223. 1928.

Corticium sebacinaeforme Bourd. & Galz., Hym. Fr. p. 224. 1928 (!!).

Corticium pruina Bourd. & Galz., Hym. Fr. p. 224. 1928 (!!).

Xenasma pruina (Bourd. & Galz.) J. Eriks., Symb. Bot. Upsal. **16**(1): 65. 1958 (!); M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 105. *fig. 93.* 1960.

Fructification effused, thin, in section 15–60 μ thick, white or Cartridge Buff to Cream-Buff, subglaucous, under a lens appearing ceraceous-pruinose to gelatinous-membranous, older portions often finely cracked, adnate; hyphae parallel to the substratum, nodose-septate, 1.5–2.5 μ in diam, conglutinate or the walls becoming gelatinized; basidia cylindrical to subclavate, borne directly on the horizontal hyphae, the base bifurcate, often obscure, (6–)7.5–12(–12.5) × 4–4.5(–5) μ, bearing four slender sterigmata 3.5–5(–6) μ long; basidiospores hyaline, the wall smooth, nonamyloid, short-allantoid to oblong-ellipsoid and laterally depressed, 4–4.5 × 2.5–3 μ.

On decayed wood and bark of *Alnus, Castanea, Corylus, Juglans,* and *Quercus.* Known from France, Sweden, and Panama.

Specimens examined: France: Aveyron, 28.VIII.1911, *Galz. 9880* (Bourd. 30039; PC); Boutaran, Aveyron, 9.IX.1914, *Galz. 16037* (Bourd. 30049, LECTOTYPE of *C. grisellum;* PC); St. Priest, Allier, 18.VI.1912, *Bourd. 30466* (LECTOTYPE of *C. pruina;* PC); Moncan, Aveyron, 19.III.1912, *Galz. 11077* (Bourd. 8690, LECTOTYPE of *C. sebacinaeforme;* PC).

Sweden: *B. & J. Eriks. 3320* (as *X. pruina*).

Panama: Prov. Chiriqui: Valley of upper Rio Chiriqui Viejo, 1600–1800 m, 28.VI.1935, *G. W. Martin 2070* (as *X. grisellum;* IA; D. P. Rogers; A. E. Liberta).

Although *X. grisellum* closely resembles *X. subnitens* in texture and basidial morphology, the two are easily separated by spore morphology.

In this analysis, *C. pruina, C. sebacinaeforme,* and *C. grisellum* were found to coincide with one another in all respects. In all three species, the spores were of two types: short-allantoid, and ellipsoid with one side depressed. Therefore, *C. pruina* and *C. sebacinaeforme* have herein been reduced to synonymy.

The notations on the jacket of *Galz. 16037* coincide with the measurements given at the time *C. grisellum* was first described. It is there-

fore designated lectotype. *Bourd. 30466* is designated the lectotype of *C. pruina* for the same reason.

The Bourdot herbarium contains two collections under the name *C. sebacinaeforme*. A fungus quite different from the description of this species was found in one of these collections. The second collection corresponded to the original description and has been therefore designated lectotype.

SPECIES EXCLUDENDAE

As already mentioned in the introduction, the members of section *Athele* that do not have affinities in the genus *Xenasma* will be discussed in a later paper. However, the species of *Xenasma* which have been excluded on the basis of this analysis are discussed below.

XENASMA MINUTUM J. Eriks., Symb. Bot. Upsal. **16**(1) : 65. *fig. 13, r–t.* 1958 (!); M. P. Christiansen, Dansk Bot. Arkiv **19**(2) : 103. *fig. 91.* 1960.

In all probability, this species was placed in *Xenasma* because of the conglutinate or gelatinized condition of the hyphae. However, the obpyriform basidia with a basal septum are quite different from the nonseptate, rooted, cylindro-clavate basidia of the species herein included in *Xenasma*.

In addition to the type locality, this species has been collected in Quebec, Connecticut, Massachusetts, and Oregon. I tentatively suggest that it be placed temporarily in the genus *Peniophora* until further studies can determine its exact taxonomic position.

XENASMA AURANTIACUM M. P. Christiansen, Dansk Bot. Arkiv **19**(2) : 107. *fig. 96.* 1960.

Judging from the description and illustrations of this species, it is not closely related to any of the species herein placed in *Xenasma*. First, the basidia are described and illustrated as occurring in clusters. This type of basidial development is quite different from that found among the members of *Xenasma*. Secondly, the hyphae are illustrated as being quite distinct rather than indistinct in an agglutinated mass.

I tentatively suggest that it be temporarily placed in the genus *Corticium* until its exact affinities can be determined.

XENASMA PYRIFORME M. P. Christiansen, Dansk Bot. Arkiv **19**(2): 108. *fig. 97.* 1960.

This species is excluded from *Xenasma* for essentially the same reasons discussed above under *X. aurantiacum*. The hyphae of *X. pyriforme* are described as "rather distinct," and illustrated to show branching very similar to that found in members of the genus *Pellicularia* Cke. emend. Rogers. In addition, the illustration of the basidia indicates that these structures are produced in heads rather than borne directly on the horizontal hyphae.

SUMMARY

The manner of basidial development, the basidial morphology, and the conglutinate or gelatinized condition of the hyphae were found to be a combination of characters which are taxonomically significant in determining the limits of *Xenasma*. As herein delimited, this genus is considered to be a natural taxon now composed of twenty species. The generic description has been expanded somewhat to include both non-amyloid- and amyloid-spored species, and to include gloeocystidiate species. Three species previously placed in *Xenasma* have been excluded.

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SOIL FUNGI FROM ORISSA (INDIA)—I

G. R. Ghosh and B. G. Dutta

Little or no work has been done in Orissa on the fungal flora of soil. This paper is a preliminary study of soil fungi from five localities of Cuttack city. Cuttack is situated between the 20.48°N latitude and 85.56°E longitude. It is a city of approximately 23 square miles and is bounded by the river Mahanadi and its branch Kathjuri. The ground level of the city is almost equal to those of the river beds. In general, the soil of the city is sandy loam but is alluvial at certain places. The climate is tropical and the average annual rainfall is 45 inches.

MATERIALS AND METHODS

Soil samples were collected from five different sites. The surface litter was scraped off by means of a sterile glass slide, then sterile culture tubes were thrust into the soil six inches (Farrow, **1954**). The tubes were plugged and stored in a sterile chamber. Two pounds of soil were collected from each place for physical and chemical analyses.

The soil from the culture tubes was transferred to sterile petri dishes and properly mixed. For isolation of fungi, 5–15 mg of soil was added aseptically into a sterile petri dish. When the soil was clayey, sterile water was added on the soil and then 12–15 cc of cooled medium was poured over the soil and homogenized (Warcup, **1950**). The plates were incubated at room temperature. To isolate the maximum number of species present in a particular sample of soil, the soil was inoculated to the culture media several times. Two media have been used, (1) soil-grass agar medium (Farrow, **1954**), and (2) rose-bengal streptomycin agar medium (Martin, **1950**). Growth on rose-bengal streptomycin agar started within two days but was delayed to four to five days in soil-grass agar. Species of Aspergilli and Penicillia were subcultivated on Czapek's solution agar and the imperfects and others on potato-dextrose agar. The original plates were kept for over a month and a number of fungi developed quite late. No attempt was made to isolate the water molds. All collections were made in November and December.

RESULTS

The results of the physical and chemical analyses and the total number of fungi isolated from five soil samples of Cuttack city are given below in TABLES I and II, respectively.

DISCUSSION

Out of the 45 fungi isolated from five soil samples 21 are additions to the Indian soil fungi. A general positive correlation was observed between the total nitrogen, organic carbon, and organic matter and the number of species isolated, except in the sample from college campus. Here the soil is sandy and fluffy and is almost dry throughout the year, so there is ample chance of spores falling from the air and gradually washing down into the earth (Burges, **1950**). No correlation was observed with nitrate nitrogen content, possibly because the content

TABLE I

RESULTS OF PHYSICAL AND CHEMICAL ANALYSES

Source of soil	Drain	Barren field near Mahanadi	Taldanda canal	Kathjuri river bed	College campus
Soil type	Black humus	Sandy loam	Sandy loam	Sandy loam & alluvial	Sandy
pH value	7.4	7.5	7.1	7.6	6.1
Water-hold. cap., %	49.9	60.2	45.08	94.3	25.8
Total N, %	0.19	0.01	0.05	0.13	0.03
Nitrate content in g ppm	1.44	2.1	1.4	1.84	0.95
Organic carbon, %	1.54	0.36	0.15	0.68	0.16
Organic matter, %	2.6	0.62	0.25	1.17	0.27

varies with the nitrification and denitrification processes.

The pH of the samples was almost uniform except for the sample from the campus and did not seem to affect the fungal population. Although it was expected that a soil with high water holding capacity would contain a larger number of fungi (Saksena, **1955**), no such correlation could be observed. This is probably due to the varied moisture contents at the time of collection. The Taldanda canal soil, Kathjuri river bed soil and drain soil were almost always saturated, the soil from barren field near Mahanadi was moderately moist, whereas the college campus soil was almost dry.

In the drain soil the imperfects dominated, the number being 14 out of 17. This might be related with the maximum organic matter content. Aspergilli were more prevalent in the college campus and Kathjuri samples. Penicillia were more prevalent in the canal sample.

TABLE II

LIST OF FUNGI ISOLATED FROM FIVE SOIL SAMPLES

Fungus	Drain	College campus	Kathjuri river bed	Barren field near Mahanadi	Taldanda canal bed
*1. *Acremonium* sp.	+	−	−	−	−
2. *Aspergillus awamori* Nakazawa	−	−	+	−	+
*3. *A. carneus* (v. Tiegh.) Blochwitz	−	+	−	−	−
4. *A. chevalieri* (Mangin) Thom & Church	−	+	−	−	−
*5. *A. fischeri* Wehmer	+	−	−	−	−
6. *A. flavipes* (Bain. & Sart.) Thom & Church	−	+	−	+	−
7. *A. flavus* Link	−	+	+	−	−
*8. *A. foetidus* Thom & Raper	−	−	+	−	−
9. *A. luchuensis* Inui	−	−	+	−	−
10. *A. nidulans* (Eidam) Wint.	−	+	−	−	−
11. *A. niger* v. Tiegh.	−	+	−	−	−
12. *A. repens* (Cda.) DBy.	−	+	−	−	−
13. *A. sydowi* (Bain. & Sart.) Thom & Church	−	−	+	−	+
14. *A. terreus* Thom	+	−	−	−	−
*15. *A. terricola* Marchal	−	−	+	−	−
16. *A. wentii* Wehmer	−	−	−	+	−
17. *Cephalosporium* sp.	+	−	−	−	−
18. *Chaetomium bostrychodes* Zopf	−	−	−	−	+
19. *Curvularia lunata* (Walker) Boed.	+	+	−	+	+
*20. *Dactylosporium* sp.	+	−	−	−	−
*21. *Fusarium merismoides* Cda.	−	−	+	−	−
22. *Fusarium nivale* (Fries) Ces.	−	+	−	−	−
23. *Fusarium* sp.	+	−	−	−	−
24. *Gliocladium deliquescens* Sopp	+	−	−	−	−
25. *Hormodendrum cladosporioides* (Fres.) Sacc.	+	−	−	−	−
*26. *H. resinae* Lindau	+	−	−	−	−
*27. *H. viride* (Fres.) Sacc.	−	−	−	+	−
*28. *Humicola grisea* Traaen	+	−	−	−	−
*29. *Mycogone nigra* (Morgan) Jensen	+	−	−	−	−
30. *Paecilomyces fusisporus* Saksena	−	−	−	+	−
*31. *Penicillium citrinum* Thom	−	+	−	+	−
*32. *P. corylophilum* Dierckx	−	−	−	−	+
*33. *P. helicum* Raper & Fennell	−	−	−	+	−
*34. *P. rubrum* Stoll	−	−	−	−	+
*35. *P. steckii* Zaleski	−	−	−	−	+
36. *Phoma glomerata* (Cda.) Wr. & Hochapfel	+	−	−	−	−
*37. *Pullularia* sp.	−	+	−	−	−
38. *Sphaeronema* sp.	+	−	−	−	−
39. *Spicaria divaricata* (Thom) Gilman & Abbott	−	+	−	−	−
*40. *Stemphylium dendriticum* Camera	−	−	+	−	−
*41. *Talaromyces spiculisporus* Lehmen	+	−	−	−	−
42. *Trichoderma koningi* Oud.	−	−	+	−	−
43. *Trichoderma lignorum* (Tode) Harz	+	−	+	−	−
44. Unidentified (Deuteromycetes)	−	−	−	+	−
45. Unidentified (Deuteromycetes)	−	−	−	+	−
Total No. of fungi isolated from each soil	16	12	10	9	7

* New records for Indian soil fungi.

The prevalent fungi in the soil samples investigated in descending order are, *Aspergillus niger* group, *A. flavus, A. flavipes, A. terreus, Penicillium citrinum, Curvularia lunata* and the Fusaria.

SUMMARY

Five soil samples have been physically and chemically analyzed and their fungal flora determined. Of the 45 fungi isolated 21 are new records in India from soil. A positive correlation has been observed between the total nitrogen, carbon and organic matter content and the number of species isolated, but no correlation has been observed between the pH value, water holding capacity, and the nitrate nitrogen content.

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SOME SPECIES OF TOMENTELLA FROM NORTH AMERICA

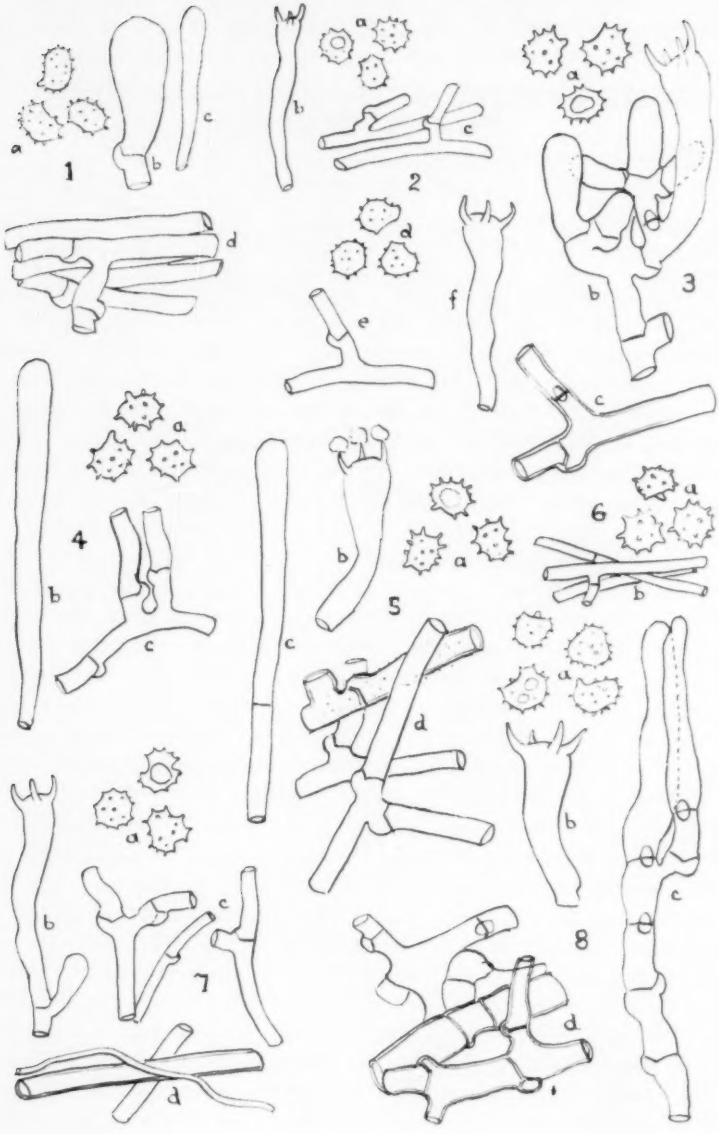
ELSIE M. WAKEFIELD

(WITH 14 FIGURES)

Since the publication of Burt's monograph of the genus *Hypochnus* (i.e., *Hypochnus* Fr. emend. Karst.) in his series of papers on the Thelephoraceae of North America (**2**), there has been no extensive work on American species of this genus, now known more correctly as *Tomentella* Pat. It is not necessary here to go into the reasons for rejecting Burt's use of the name *Hypochnus,* since this has been fully explained by Rogers (**6**), and also in work published by the Nomenclature Committee of the British Mycological Society (**1**) and by Donk (**3**, **4**).

The writer became interested in the genus *Tomentella* some years ago after receiving some unusual species from collectors in Britain, and she has since tried to see the type material of as many as possible of the described species. For the loan of material named by American mycologists she is indebted to the late Dr. D. H. Linder, who sent the type specimens, now in the Farlow Herbarium, of species described by Burt, and more recently to Dr. I. Mackenzie Lamb, who supplied type material of *Hypochnus sparsus* Burt, omitted from the original sending. She is also especially indebted to Dr. D. P. Rogers, who when at the Herbarium of The New York Botanical Garden (NY) sent not only all the material included there under *Hypochnus* and *Tomentella,* but also that classified under *Zygodesmus.* Rogers (**7**) had already indicated that many species of *Tomentella* might be found among material assigned to *Zygodesmus* Corda sensu Saccardo, a genus classified among the Hyphomycetes. J. B. Ellis appears to have taken a special interest in *Zygodesmus,* by which he understood fungi (regarded as Imperfectae) having clamp-connections and warted or spiny spores, and in the Ellis collection at New York are numerous specimens named by Ellis as *Zygodesmus,* which are undoubtedly species of *Tomentella.* Some of Ellis's new species were validly published, but in his collection there are found also numerous unpublished names.

Examination of all this material has shown that the North American



FIGS. 1–8.

fungus flora includes more species of *Tomentella* than were known to Burt in 1916. Further, the descriptions of some species need to be revised, and on the other hand some names, especially in *Zygodesmus*, must be relegated to synonymy. The present paper seeks only to record some of the results obtained from examination of this North American material. One new species is described, and three new combinations have been made, for two of which Latin diagnoses are also supplied because of the inadequacy of the original descriptions. The capitalized color terms used are those of Ridgway (**5**). Spore measurements are those of the body of the spore, without ornamenting spines or warts.

REVISIONS AND NEW RECORDS

Tomentella corticioides Wakef., sp. nov. FIG. 1

Zygodesmus corticioides Ell. & Ev. nom. ined. in Herb. New York Bot. Garden.

Sporophorum irregulariter effusum, crassum, subiculo cinnamomeo-brunneo, hymenio compacto, ochraceo. Hyphae basales umbrinae, rectae, interdum fasciculatae, septato-nodosae, 3–5 μ diam. Hyphae subhymeniales hyalinae, tenuiter tunicatae, 3–5 μ diam. Basidia matura non visa; basidia juvenilia hyalina, clavata, sursum 10–13 μ latae, hyphis 3–5 μ latis intermixtis. Sporae oblongae, uno latere depressae, umbrinae, aculeis numerosis minutis acutis ornatae, 8–9(–10) × 5.5–7 μ Hab. Ad ramos emortuos et ad terram.

Irregularly effused, rather thick and compact, with a dark subiculum (cinnamon-brown) covered by a smooth, compact, paler hymenium (Light Ochraceous Buff). Basal hyphae umber-brown, straight, rather thick-walled, with clamp-connections at the septa, 3–5 μ diam, sometimes forming dark cords. Subhymenial hyphae almost hyaline, thin-walled, 3–5 μ diam. Mature basidia not seen, probably collapsed; young basidia hyaline, clavate, 20–30 × 10–13 μ above, intermixed with blunt hyphal

FIGS. 1–8. *Tomentella* spp. 1. *T. corticioides* Wakef. TYPE. a, spores; b, young basidium; c, paraphysis; d, basal hyphae. 2. *T. Jaapii* (Bres.) B. & G. a–c, TYPE; d–f, "*Zygodesmus sublilacinus* Ell. & Holw. var. *granulosus*." 3. *T. fusco-ferruginosa* (Bres.) Litsch. a, spores; b, basidia; c, basal hypha. (Ohio, W. B. Cooke 2425.) 4. *T. muricata* (Ell. & Ev.) Wakef., TYPE. a, spores; b, cystidium; c, hyphae. 5. *T. muricata* (as "*Zygodesmus sublilacinus*," Newfield, 1897). a, spores; b, basidium; c, cystidium; d, hyphae. 6. *T. mucidula* (Karst.) v. H. & L. (Lake Timagami, Ont.). a, spores; b, hyphae. 7. *T. subrubiginosa* Litsch. (Norwich, Ont.). a, spores; b, basidium; c, subhymenial hyphae; d, basal hyphae. 8. *T. sublilacina* (Ell. & Holw.) Wakef., TYPE. a, spores; b, basidium; c, subhymenial hyphae and paraphyses; d, basal hyphae. (All drawn with camera lucida, × 1000, reduced by two-thirds.)

ends, 3–5 μ wide. Spores oblong, with one side depressed, umber-brown like the basal hyphae, echinulate, with minute, crowded spines, 8–9(–10) × 5.5–7 μ.

In habit this species closely resembles *T. fuliginea* (Burt) Bourd. & Galz., and the Dutch specimen cited was so determined by the late V. Litschauer. The most obvious difference is in the spores: in *T. fuliginea* they are globose, while in the fungus in question they are large and distinctly oblong or elliptical.

Specimens examined: Texas, San Antonio. On the ground, *Dr. Egeling*, Sept. 1890 (in Ellis Collection, NY, TYPE); Holland, Utrecht. On rotten branches of *Quercus* on the ground, leg. *H. Hirsch*, 14. 9. 1932 (in Herb. M. A. Donk No. 3483, as "*T. fulginea* (Burt) B. & G.").

TOMENTELLA FUSCO-FERRUGINOSA (Bres.) Litschauer, Ann. Mycol. **39**: 377. 1941. FIG. 3

Hypochnus fusco-ferruginosus Bres., Ann. Mycol. **1**: 109. 1903.

Sporophore rather thick, soft and spongy, widely and irregularly effused, with no distinct margin, fairly closely adherent, but separable in fragments, consisting of a dark, almost black subiculum, overlaid by a paler hymenium. Hymenium at first rather loose and pulverulent, later becoming more compact and smooth, in color Snuff Brown, Buffy Brown, Antique Brown or Buckthorn Brown. Hyphae smooth, with frequent clamp-connections; the basal hyphae dark reddish-brown by transmitted light, rather rigid, thick-walled, frequently septate, and branched more or less at right-angles; the subhymenial hyphae paler, yellowish to pale fuscous, thinner-walled, frequently septate and branched, 4–6 μ in diameter. Basidia large, clavate, flexuous, hyaline to yellowish, 50–65 × 7–10 μ, with four long, curved sterigmata, 7–10 × 2–2.5 μ. Spores globose or subglobose, elliptical in side view, sometimes angular or sinuate in outline, with a large, blunt hyaline apiculus, dark yellow-brown or reddish-brown by transmitted light, thin-walled, strongly echinulate with scattered, pointed spines, the body 8–10(–12) × 7–8(–9) μ, often with a large oil-drop.

Hab. on rotting wood of deciduous trees.

The species differs from *T. pallidofulva* (Peck) Litsch. (= *T. ferruginea* sensu Pat.) in the less bright rust color of the hymenium and the presence of a dark, spongy subiculum, also in the spores, which are not evenly globose and are darker in color. The yellowish color of the hymenium is dissolved out by dilute KOH solution, but there is no trace of a change to green or blue.

Specimens examined: Canada. On dead wood, 28. 9. 1897, *Macoun*

195 (as "*Zygodesmus fulvus* Sacc." in Ellis Collection, NY); Ohio, Horner Run, Clermont Co. On rotten wood, leg. *W. Bridge Cooke*, No. 2425 (as "*T. ferruginea* (Pers.) Schroet.," NY).

TOMENTELLA JAAPII (Bres.) Bourd. & Galz., Bull. Soc. Mycol. Fr. **40**: 155. 1924. FIG. 2

Hypochnus Jaapii Bres. in Jaap, Fung. Sel. Exs. 1905.

Tomentella papillata v. Hoehn. & Litsch., Sitz. ber. K. Acad. Wiss. Wien **117**: 1118. 1908.

Sporophore effused, membranaceous when dry and separable in small pieces, Cinnamon Buff, Cinnamon or Wood Brown to Verona Brown or Sayal Brown, the hymenium loose and pulverulent at first, later more compact and granular. Hyphae rather straight and sparsely septate, with clamp-connections, 2.5–5(–6) μ in diameter, hyaline to pale yellowish brown. Basidia hyaline or pale yellowish, narrowly clavate, flexuous, 30–55 × 6–8 μ above, with four curved sterigmata, 5–6 μ long and 1.5–2 μ wide at the base. Spores yellowish- or reddish-brown, sinuate or angular in outline, thin-walled, usually containing one large oil-drop, the wall ornamented with loosely arranged, small, hyaline spines, 7–9 × 5–8 μ.

Hab. on fallen dead twigs and branches, chiefly of dicotyledonous trees. Easily recognized by the color and the granular hymenium.

Specimen examined: Minnesota, Vermilion Lake. On birch, leg. *Holway*, July 26, 1886 (as "*Zygodesmus sublilacinus* Ell. & Holw. var. *granulosus*" in Ellis Collection, NY).

TOMENTELLA MUCIDULA (Karst.) v. Hoehn. & Litsch., Sitz.-ber. K. Akad. Wiss. Wien **115**: 1572. 1907.

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Hypochnus roseo-griseus Wakef. & Pears., Trans. Brit. Mycol. Soc. **6**: 141. 1919.

Tomentella roseo-grisea (Wakef. & Pears.) Bourd. & Galz., Bull. Soc. Mycol. Fr. **40**: 143. 1924.

Sporophore effused, thin, soft, pellicular or membranaceous, easily separable, hymenium when fresh between Light Vinaceous Fawn and Cinnamon Drab, with a paler Drab Grey margin. Hyphae very fine, without clamp-connections at the septa, the subhymenial hyphae almost hyaline, the basal hyphae pale greyish, sparsely septate and not much branched, 2.5–3 μ in diameter. Basidia subhyaline, clavate, 40–55 × 7–10 μ, with 2 to 4 slightly curved sterigmata 7–9 μ long. Spores subglobose or slightly angular, hyaline or pale yellowish, often containing a single oil-drop, ornamented with scattered, conical warts, 7–9(–10) μ in diameter.

Hab. on bark and wood of fallen branches, chiefly of conifers.

The species belongs in the section *Tomentellastrum,* characterized by the absence of clamp-connections. Recently Svrček (**9**, p. 67) has made it the type species of a new genus *Pseudotomentella,* which he distinguishes from *Tomentellastrum* (also elevated to generic rank) merely by the pale color of all parts.

Specimens examined: Canada, Lake Timagami, Bear Island, Ont. *On Thuja occidentalis,* leg. *R. F. Cain,* No. 2402, 10. 9. 1933 (NY); Canada, Ironsides. On very rotten wood, leg. *J. Macoun,* 18. 9. 91 (NY).

Tomentella muricata (Ell. & Ev.) Wakef., comb. nov. FIGS. 4, 5

Zygodesmus muricatus Ell. & Ev., Bull. Torrey Bot. Club **11**: 17. 1884.

Sporophorum parum effusum, mollissimum, floccosum, facile separabile, siccum avellaneum vel griseo-brunneum. Hymenium sub lente pulverulentum vel vix granulosum, non continuum. Subiculum arachnoideum, brunneum. Hyphae septato-nodosae, aliquando subincrustatae; hyphae basales pallide umbrinae, subrectae, sparse septate, 4–6 μ diam, interdum fasciculatae; hyphae subhymeniales hyalinae vel pallidae, frequenter septatae, nodis magnis, 5–7 μ latae, interdum ad septa ad 10 μ inflatae. Basidia hyalina, clavata, 25–40 × 7–9 μ, sterigmatibus 4, curvulis, 3.5–4 μ longis. Cystidia elongata, anguste clavata, septata, deorsum 3–4 μ, ad apicem 6–7.5 μ diametro. Sporae oblongae vel ellipticae, uno latere depressae, pallide brunneolae, echinulatae, aculeis sparsis, obtusis, 1–2 μ longis ornatae, apiculo hyalino brevi, 7–9 × 5–7 μ (sine aculeis).

Hab. ad lignum cariosum Pini, vel rarius Querci.

The species is very soft, loose and easily separable, forming more or less rounded patches on rotten wood and bark. Originally described as "purplish rose-color, becoming light buff," herbarium specimens are now Drab to Wood Brown or Buffy Brown. The hymenium, pulverulent or slightly granular under the lens, is seated on an arachnoid subiculum, visible especially at the margin, where it is more brownish in color than the hymenium. The basal hyphae, 4–6 μ in diameter, are

rather straight, pale dull brownish in color, sometimes encrusted with granules, sparsely septate, with clamp-connections, and often united to form cords. The subhymenial hyphae are pale to hyaline, more frequently septate, with large clamp-connections, 5–7 μ in diameter, at the septa sometimes inflated to 10 μ. Basidia hyaline, clavate, 25–40 × 7–9 μ, with four, slightly curved sterigmata 3.5–4 μ long. Cystidia elongated, narrowly clavate, once or twice septate, 6–7.5 μ at the apex, 3–4 μ below. Spores oblong or elliptical, flattened on the inner side, pale brownish, with conspicuous scattered blunt hyaline spines 1–2 μ long, and a short blunt hyaline apiculus, 7–9 × 5–7 μ. There is no change of color with alkaline solutions.

T. muricata is very close to a species from the Tirol which was named *T. clavigera* by Litschauer, but apparently never described. It differs from that species and from *T. subclavigera* Litsch. in the broader, colored basal hyphae, sometimes forming cords, and in the larger spores, with more scattered, blunt spines.

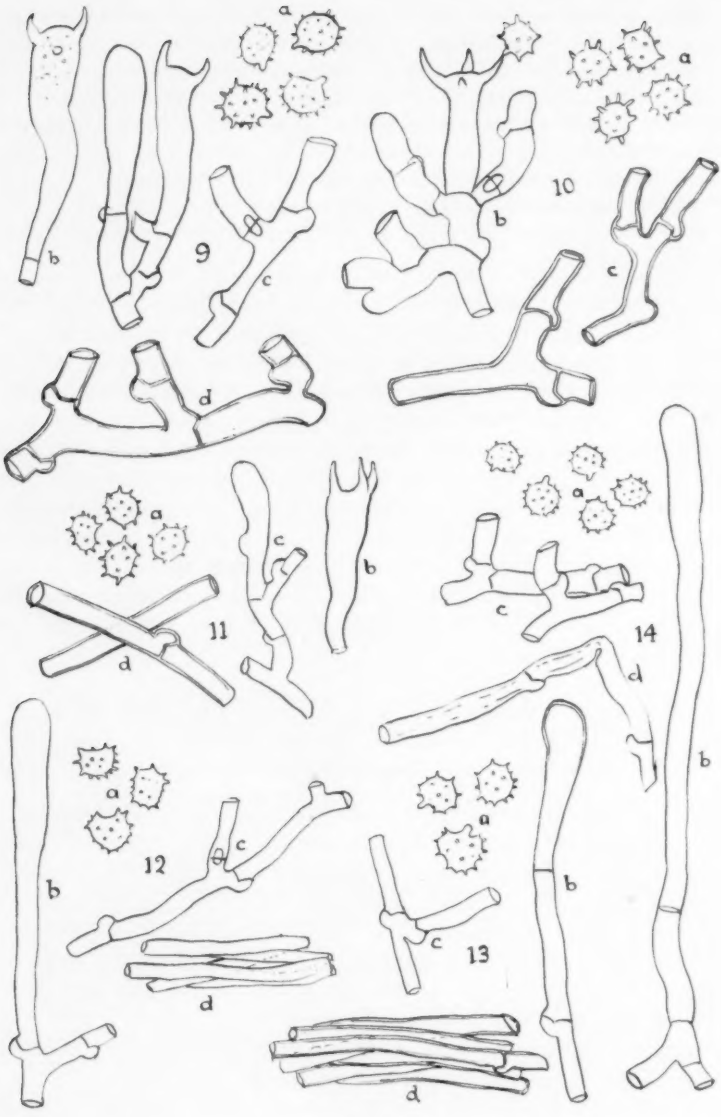
Specimens examined: New Jersey, Newfield. On rotten pine, Sept. 19th, 1883 (TYPE) in Ellis Collection, NY; New Jersey, Newfield. On rotten pine wood and bark, Sept. 4th, 1897 (as "*Zygodesmus sublilacinus* Ell. & Holw." in Ellis Collection, NY); New Jersey, Newfield. On decaying pine bark, Aug. 27, 1896 (as "*Zygodesmus lilacinus* Ell. & Ev." in Ellis Collection, NY); New Jersey, Newfield. On rotten oak, Dec. 1881 (as "*Zygodesmus lilacinus* Ell. & Ev." det. Sumstine in Ellis Collection, NY).

TOMENTELLA PILOSA (Burt) Bourd. & Galz., Bull. Soc. Mycol. Fr. **40**: 151. 1924; Hymen. de Fr. 500. 1927. FIGS. 12, 13
Hypochnus pilosus Burt, Ann. Missouri Bot. Gard. **3**: 221. 1916.

Like *T. muricata* and *T. subclavigera* this species is characterized by the presence of emergent, clavate, septate cystidia, but in *T. pilosa* all parts (hyphae, cystidia, basidia and spores) are colored from yellowish to brown. Burt described the hyphae as "somewhat longitudinally interwoven next to the substratum." Actually the hyphae form distinct mycelial cords, and on this account, as well as the color, the species seems to fit better into the section *Chordulatae* of Bourdot and Galzin, than into the section *Discolores* where they placed it.

Amongst the material sent by Dr. Rogers from New York two additional records from North America were found.

Specimens examined: Wisconsin, Lake Geneva. On bark of decaying *Quercus alba*, leg. *E. T.* and *S. A. Harper*, No. 877, July 1903 (TYPE); without locality. "On old *Polyporus pergamenus* DC.," leg.



FIGS. 9–14.

Sumstine, 15. 7. 1910 (as "*Zygodesmus echinatus* E. & E.," nom. ined. in Ellis Collection, NY). The substratum appears to be a brown Polypore, surely not *P. pergamenus*; Canada, London, Ont. On basswood, leg. *Dearness,* 31. 8. 1889, No. 676 (as "*Zygodesmus*" unnamed, in Ellis Collection, NY).

Tomentella ramosissima (Berk. & Curt.) Wakef., comb. nov. FIG. 10

Zygodesmus ramosissimus Berk. & Curt., Grevillea **3**: 145. 1875.

Sporophore effused, loose and spongy in texture, the general color fuscous, at first very thin, later up to 0.25 mm thick and easily detached from the substratum. Hymenium pulverulent under a lens, slightly paler than the very dark (blackish) subiculum. Hyphae flexuous, much branched, the branches often opposite, and frequently septate, with clamp-connections at every septum. Basal hyphae dark brown (Bister), thick-walled, 5–7(–10) μ wide, often geniculate, rigid, sometimes forming cords. Subhymenial hyphae erect, much branched, the branches often opposite, very frequently septate, with short segments, dark brown below, but becoming paler as they pass into the hymenium, 5–6(–8) μ wide. Basidia hyaline to pale brownish, cylindrical, 27–30 × 7 μ, with four long, curved sterigmata 8–10 μ long and 2 μ wide at the base. No cystidia. Spores pale fuscous or bister, rounded or somewhat angular in face view, 7–7.5 μ diam, or oblong when seen from the side 7–9 × 6–7 μ, echinulate with scattered, colorless, conical spines, about 1.5–2 μ long, and with a small basal apiculus.

Hab. on rotten wood and bark.

The original specimen of *Zygodesmus ramosissimus* forms a very thin layer on rotten wood, and presumably represents a young state. The other specimens here identified as the same are thick and spongy, with very coarse hyphae in the subiculum. The structure is reminiscent of *T. Ruttneri,* but the general color and the color of the hyphae are much darker, the spores less evenly rounded and with stronger spines.

FIGS. 9–14. *Tomentella* spp. 9. *T. Ruttneri* Litsch. (Newfield, on magnolia). a, spores; b. basidia; c, subhymenial hyphae; d, basal hyphae. 10. *T. ramosissima* (Berk. & Curt.) Wakef. (Virginia, as "*Zygodesmus grisco-purpureus*"). a, spores; b, basidia; c, hyphae. 11. *T.* ? *rhodophaea* v. H. & L. ("*Zygodesmus carneus*" Ell. nom. ined.). a, spores; b, basidium; c, paraphysis; d, basal hyphae. 12. *T. pilosa* (Burt) B. & G., TYPE. a, spores; b, cystidium; c, hyphae; d, basal hyphae forming cords. 13. *T. pilosa* (Burt) B. & G. (London, Canada, Dearness 676). a, spores; b, cystidium; c, subhymenial hyphae; d, basal hyphae forming cords. 14. *T. subclavigera* Litsch. (Chocorua, N. H., Farlow 16, as "*Hypochnus sparsus*"). a, spores; b, cystidium; c, subhymenial hyphae; d, basal hypha. (All drawn with camera lucida, × 1000, reduced by two-thirds.)

The chief characteristics of the present species seem to be the dark, blackish color, the spongy texture, the coarse, dark hyphae and the strongly spiny spores. *T. atramentaria* Rostr. would appear to be similar in color and in structure, but the spores, as described by Skovsted (**8**) are larger and more elliptical. I have not seen type material of this species.

Specimens examined: Carolina Inf. No. 2274 on pine wood (TYPE of *Zygodesmus ramosissimus* in Herb. Kew); Virginia, Mts. On rotten wood, August 1890, leg. *Dr. Rex* (as "*Zygodesmus griseo-purpureus* E. & E.," nom. ined., in Ellis Collection, NY); Delaware. At base of small trees in woods, Oct. 15, 1887, leg. *A. Commons* No. 716 (as "*Zygodesmus fuscus*" in Ellis Collection, NY); Pennsylvania, West Chester. leg. *E. H. J.* and *G.* No. 301, Oct. 1881 (as "*Zygodesmus fuscus*" in Ellis Collection, NY).

TOMENTELLA CFR. RHODOPHAEA v. Hoehn. & Litsch. in Sitz-ber. K. Acad. Wiss. Wien **105**: 831. 1907. FIG. 11

Sporophore resupinate, thin, at first in small patches which later become confluent, separable as a rather soft membrane. Hymenium Pinkish Buff or becoming fawn to Wood Brown, pulverulent or even slightly tufted under a lens, the margin cream-colored, gradually becoming thinned out, sometimes with spreading cream-colored cords. Hyphae hyaline, with clamp-connections. Basal hyphae straight, horizontal, sparsely septate with occasional clamp-connections (not at every septum), rather thick-walled, 4–5 μ wide, sometimes forming cords. Subhymenial hyphae thin-walled, flexuous, branched and frequently septate, with rather large clamp-connections, 3–4 μ wide. Basidia hyaline, clavate, 30–40 $\times$ 6–7 μ above, with 2 to 4 sterigmata 5–7 μ long and 1.5–1.75 μ wide at the base. Spores very pale clear brownish, broadly elliptical or rounded and slightly sinuate in outline, echinulate with scattered hyaline spines 1–1.5 μ long, 6.5–7(–8) $\times$ 5–6 μ. No change of color when treated with alkalies.

The general coloring of this fungus suggests *T. cervina* (Burt) Bourd. & Galz., but both specimens examined differ from *T. cervina* in being larger, separable as a soft membrane, and in giving no trace of a color-change when sections are treated with dilute KOH solution. The reference to *T. rhodophaea* is not at all certain, since the original specimen of that species (the only collection known) differs in growing on poplar wood, in the pale rose-colored margin, the slightly larger hyphae (up to 6 μ) and the clear-greyish brown basal hyphae.

Specimens examined: New Jersey, Newfield. On bark of decaying

pine logs, Dec. 13, 1879, leg. *J. B. Ellis* (as "*Zygodesmus carneus* Ell.," nom. ined. in Ellis Collection, NY); Canada. On rotten decorticated wood (coniferous), leg. *Macoun*, No. 122 (as "*Zygodesmus sublilacinus* Ell. & Holw." in Ellis Collection, NY).

TOMENTELLA RUTTNERI Litsch., Bull. Soc. Myc. Fr. **49**: 67. 1933. FIG. 9

Sporophore effused, thin, soft, adnate, in color from Cinnamon Brown or Snuff Brown to Prout's Brown, with no distinct margin. Hymenium slightly paler than the subiculum, at first pulverulent under the lens, becoming more compact and smooth. Basal hyphae dark brown or reddish brown, much branched and shortly septate, with clamp-connections, 6–8 μ in diameter, sometimes inflated up to 10 μ near the septa. In the original material of this species some of the basal hyphae are thick-walled, but I have been unable to see the "bistratose" wall described by Litschauer—it appears to have been an optical effect. Subhymenial hyphae paler, frequently septate, with clamp-connections, 5–6.5(–8) μ in diameter. Basidia hyaline or very slightly colored yellowish to pale fuscous, elongated clavate, when young with granular contents, 40–55(–60) × 10–12 μ above, with four stout pointed and slightly curved sterigmata, 8–10 μ long and 2.5–3.5 μ wide at the base. Spores umber-brown like the hyphae, subglobose or in side view elliptical with the inner side flattened, 8–9 μ in diameter or 9–10 × 7–8 μ, often containing a large guttule, echinuate with numerous hyaline spines, and attached to the sterigma by a hyaline basal apiculus. No cystidia present. The American specimens seen sometimes show a slight evanescent blue-green color when sections are treated with KOH solution, but this is not constant.

Hab. on rotten wood.

The species is characterized by its color, by the large hyphae and basidia, and the large subglobose spores ornamented with distinct, scattered spines. It was originally described on *Abies Bornmulleriana* from Asiatic Turkey, and has been recorded from Sweden on coniferous wood. American specimens are evidently not confined to conifers. The specimen on magnolia is accompanied by a written description in which the color is said to be "vinous purple or dark lilac" when fresh, hence the epithet *lilacinus* given by Ellis. The dried specimens are now brown, as are European specimens of *T. Ruttneri*.

Specimens examined: New Jersey, Newfield. On rotten magnolia, July 23, 1889 (as "*Zygodesmus lilacinus* Ell. & Ev.," nom. ined. in Ellis Collection, NY); Louisiana, near St. Martinsville. On rotting

pieces in a damp wood, leg. *A. B. Langlois,* 23. IX. 1889, No. 2123 (as "*Zygodesmus lilacinus* Ell. & Ev." in Ellis Collection, NY).

TOMENTELLA SUBCLAVIGERA Litsch., Bull. Soc. Mycol. Fr. **49**: 57. 1933. FIG. 14

Sporophore very thin, interruptedly effused, soft, closely adnate, drab, pulverulent under the lens, the margin similar, indefinite. Hyphae hyaline, with clamp-connections. Basal hyphae somewhat flexuous, 4–5 μ wide, thick-walled, the walls highly refractive; subhymenial hyphae frequently septate, with clamp-connections at every septum, branched, irregular, 3–6.5 μ wide. Basidia hyaline, clavate, 6–8 μ wide above, with four slender, slightly curved sterigmata 3–6 μ long, 1.5 μ wide at the base. Cystidia present, but not at all abundant, hyaline, elongated clavate, blunt at the apex and 7–9 μ wide above, up to 165 μ long, originating from the subhymenial hyphae and projecting up to half their length above the hymenial surface, once or twice septate below the middle. Spores subglobose, fairly even in outline or sometimes slightly sinuate, pale smoky-brown, thin-walled, with a blunt basal apiculus, and ornamented with crowded, minute spines or prickles, 6.5–7.5(–9) × 6–7 μ.

Hab. on rotten wood.

The species differs from *T. muricata* in the more scanty, adnate sporophore, the smaller and more even spores with smaller and more crowded spines, and in the absence of mycelial cords. The specimen here described was included by Burt under his *Hypochnus sparsus* (**2**, p. 226). The type specimen of *Hypochnus sparsus* (Farlow No. 15) is unfortunately very scanty. I have examined it but have been unable to find any cystidia or any thick-walled basal hyphae, nor did Burt make any mention of such. The spores in the type specimen are a little darker brown than those of *T. subclavigera,* contrasting strongly with the hyaline hyphae, and are slightly more angular in shape, with less crowded spines. It seems probable that the true *Hypochnus sparsus* is a species distinct from *T. subclavigera* and that the citation of this specimen (Farlow 16) under *H. sparsus* was a mistake on the part of Burt. The collection and study of more American material are, however, desirable. It may be noted that Svrček (**9**, p. 73) has recently recorded under the name *Tomentella sparsa* (Burt) Svrček a specimen (unlocalized) which he places in the section *Bolares* of Bourdot & Galzin.

Specimen examined: New Hampshire, Chocorua. On rotten bare wood, leg. *W. G. Farlow* Sept. 1906, No. 16 (as "*Hypochnus sparsus* Burt" in Farlow Herbarium).

Tomentella sublilacina (Ell. & Holw.) Wakef., comb. nov. FIG. 8

Zygodesmus sublilacinus Ell. & Holw., Arthur et al., Minn. Geol. Nat. Hist. Surv. Bull. **3**: 34. 1887.

Sporophorum irregulariter effusum, molle, ad 0.5 mm crassum, sicco rubro-brunneum ("Verona Brown"), margine non manifesto. Hymenium fertile pallidius ("Wood brown"), primo sub lente pulverulentum deinde laeve, compactum. Hyphae semper plus minus erectae, contextum sat firmum formantes, pallide brunneae vel rubro-brunneae, infra crasse supra tenuiter tunicatae, subhymeniales ramosissima, irregulares, frequenter septatae, 4–7 μ diam, saepe ad 10 μ prope septa inflatae, septato-nodosae. Basidia clavata, hyalina vel pallide brunneo-tincta, 50–55 × 10–11 μ, tetra-sterigmatica. Sterigmata conica vel subarcuata, 3–7 μ longa, in loco insertionis 2–2.5 μ crassa. Inter basidia adsunt paraphyses (hypharum termini) subcylindricae, apicibus obtusis, circa 40 × 4–6 μ. Sporae angulatae, sinuatae, rotundatae vel subtriangulares, sed oblique visae uno latere applanatae et plus minus oblongae, distincte hyalino-apiculatae, rubro-brunneae, minute echinulatae, 8–8.5 × 6–8 μ.

Hab. ad lignum cariosum.

Sporophore irregularly effused, with no distinct margin, rather thick (up to 0.5 mm), soft, felted, the general color about Verona Brown when dry. The fertile hymenium is paler in color (about Wood Brown), at first pulverulent under the lens, later smooth and compact. Hyphae all more or less erect, forming a rather compact tissue with no distinct horizontal basal hyphae. Hyphae colored pale clear brown or reddish-brown, thick-walled below, thinner-walled and much branched beneath the hymenium, irregular, frequently septate with very short segments, 4–7 μ in diameter, often inflated up to 10 μ towards the septa, with clamp-connections at every septum. Basidia clavate, colorless or pale brownish, 50–55 × 10–11 μ above, with four short conical or slightly curved sterigmata, 3–7 μ long and 2–2.5 μ wide at the base. There are no true cystidia, but the basidia are intermixed with cylindrical hyphal ends or paraphyses, blunt at the apex, about 40 × 4–6 μ. Spores angular, sinuate, rounded to subtriangular in face view, more oblong when seen from the side, reddish-brown with a short colorless basal apiculus, 8–8.5 × 6–8 μ, echinulate with minute, crowded spines.

The species is noteworthy for the very irregular, shortly septate hyphae, often inflated, and with clamp-connections at each septum, forming a compact tissue. It differs from *T. Ruttneri* which also has broad, irregular hyphae, in the paler color and angular (not evenly globose) spores.

Specimens examined: Minnesota, Vermilion Lake. On charred wood, July 26, 1886, leg. *Holway* (TYPE, in Ellis Collection, NY); Massachusetts. On rotten decorticated wood, Jan. 1891, leg. *G. W. Newton* (as "*Zygodesmus lilacinus* E. & E." in Ellis Collection, NY).

TOMENTELLA SUBRUBIGINOSA Litsch., Bull. Soc. Sci. Skoplje **20**: 17. 1939. FIG. 7

Sporophore resupinate, irregularly effused, rather thin, soft and more or less separable, floccose-tomentose, the general color rust brown (Argus Brown or Antique Brown), more yellowish towards the margin, with a granular hymenium and a darker brown subiculum extending beyond the margin with dark cords. Hyphae yellow-brown, with here and there amorphous red-brown deposits on the walls (seen best when preparations are mounted in water or in lacto-phenol). Basal hyphae dark brown, loosely interwoven, rather thick-walled, septate with clamp-connections, 4–5 μ in diameter, sometimes forming cords, with finer hyphae intermixed; cords dark brown, much branched, sometimes abundant and visible under a lens as blackish threads. Subhymenial hyphae yellow-brown, thinner-walled, closely interwoven, septate, with clamp-connections, 2.5–4 μ in diameter. Basidia pale clear yellowish, elongated, clavate, 48–75 × 7–9 μ, with four slightly curved sterigmata 5–7(–10) μ long and 1.5–2 μ at the base. Spores reddish-brown, rounded, angular and more or less sinuate, sometimes subglobose, thin-walled, usually containing one large guttule, 6–8 μ in diameter or 7–10 × 6–8 μ, aculeate with short hyaline spines.

Hab. on rotting wood and dead leaves, etc. of dicotyledonous trees.

This species differs from *T. pallidofulva* (Peck) Litsch. in the more angular, finely aculeate spores and in the presence of dark mycelial cords. It is allied to *T. epiphylla* and *T. rubiginosa* but differs from both in the wider hyphae and in the dark basal hyphae and cords. With solutions of KOH the basidia and subhymenial hyphae give a slight greenish-yellow color.

Specimens examined: Virginia, Olivet, Armstrong Co. On *Quercus alba*, Nov. 30, 1933, leg. *L. White*, No. 2173 (as "*Hypochnus rubiginosus*," NY); Iowa, Iowa City. leg. *G. W. Martin*, Sept. 23, 1935 (as "*Tomentella rubiginosa*," NY); Pennsylvania, West Chester. On mycelium of old polypore(?), Oct. 12, 1881, *E. H. J. & G.* (as "*Zygodesmus rubiginosus* Peck var. *robustior* Ell." in Ellis Collection, NY); Canada, Norwich, Ontario. On *Tilia americana*, leg. *R. F. Cain*, Oct. 9, 1933; Long Island, Flatbush. On dead hickory bark, leg. *J. L. Zabrisk* 14. X. 1892, No. 449 (as "*Tomentella granulosa* (Peck) B. & G." in Ellis Collection, NY); West Virginia, Fayette Co. On *Carex Fraseri*, leg. *L. W. Nuttall* 2. 11. 1894 (as "*Zygodesmus graminicola* E. & E." in Ellis Collection, NY); Delaware, Wilmington. On old *Polyporus pergamenus*, leg. *A. Commons*, Sept. 11, 1893, No. 2193 (as "*Tomentella granulosa*," NY) probably this species.

SYNONYMS AND SPECIES EXCLUDENDAE

Zygodesmus carneus Ellis, nom. ined.....Probably *T. rhodophaea* v. Hoehn. & Litsch. (see notes above)

Zygodesmus echinatus Ell. & Ev., nom. ined.....*Tomentella pilosa* (Burt) Bourd. & Galz.

Zygodesmus effusus Berk. & Curt.....cannot be determined

Zygodesmus fibrosus Berk. & Curt.....*Kneiffiella bombycina* Karst.

Zygodesmus indigoferus Ell. & Ev.....*Corticium atrovirens* Fr.

Zygodesmus lilacinus Ell. & Ev., nom. ined.....*Tomentella Ruttneri* Litsch.

Zygodesmus lutosus Ell., nom. ined.....*Tomentella* sp. of the group *Cystidiolatae,* allied to *T. Galzini* Bourd. or *T. subtestacea* Bourd. & Galz.

Zygodesmus marginatus Cooke & Harkn.....*Pellicularia isabellina* (Fr.) Rogers

Zygodesmus macrochaites Ell., nom. ined.....*Tomentella spongiosa* (Schw.) Bourd. & Galz.

Zygodesmus ochraceus Sacc.....*Pellicularia isabellina* (Fr.) Rogers

Zygodesmus pelliculosus Ell. & Ev., nom. ined.....*Tomentella zygodesmoides* (Ell.) v. Hoehn. & Litsch.

Zygodesmus Pyrolae Ell. & Halst.....Type is sterile, may be a *Thelephora* sp.

Zygodesmus trachychaetes Ell. & Ev.....*Tomentella pannosa* (Berk. & Curt.) sensu orig., *non* sensu Bourd. & Galz.

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AN EMENDATION OF THE GENUS ITERSONILIA BASED ON STUDIES OF MORPHOLOGY AND PATHOGENICITY [1]

GROVER SOWELL, JR.[2] AND RICHARD P. KORF [3]

Itersonilia sp. is responsible for a serious leafspot and canker of parsnip (*Pastinaca sativa* L.) in the United States (Wilkinson, **1952**) and in England (Channon, **1956**). During the course of an investigation of the pathogenicity and life cycle of the species responsible for the parsnip disease, Sowell (**1953**, **1954**) obtained four isolates of *Itersonilia* spp. from other investigators and collected 43 isolates from parsnips growing in New York State. The present investigation was conducted to clarify the identity of these isolates and the taxonomy of the genus *Itersonilia* in relation to other, possibly closely related, genera.

REVIEW OF THE LITERATURE

The type species of the genus *Itersonilia*, *I. perplexans* Derx, was first isolated by suspending a leaf of *Althaea rosea* Cav. infected with *Puccinia malvacearum* Mont. over malt agar (Derx, **1948**). Stempell (**1935**) described a fungus which Derx believed to be a contaminant of *I. perplexans* as the "Myzel II" stage of *Entyloma calendulae* (Oud.) de Bary.

A second species of the genus was isolated from the leaves of *Acer macrophyllum* Pursh and described as *I. pyriformis* Nyland (**1950a**). The species was said to differ from *I. perplexans* in the absence of clamp connections in association with the "chlamydospores" (sporogenous cells), the production of abundant aerial mycelium on malt agar, and the

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production of ballistospores which were very slightly longer (by error Nyland wrote "shorter") than those reported for *I. perplexans.*

Olive (**1952**) identified a fungus originally isolated from *Pastinaca sativa* by Wilkinson (**1952**) as *I. perplexans* and conducted detailed morphological and cytological studies on this and a second isolate from rust-infected dewberry leaves found in Louisiana. Tubaki (**1952b**) isolated *I. perplexans* from six different hosts in Japan by suspending leaves over nutrient agar. He concluded that *Itersonilia pyriformis* is a synonym of *Itersonilia perplexans.*

MATERIALS AND METHODS

Morphology and cytology: Five representative isolates were selected from those collected by the senior author for detailed study. The origins of the selected isolates were as follows: (1) "New York isolate," from parsnip leaves showing leafspot, collected at Rochester, New York; (2) "Australian isolate," from parsnip roots showing canker, by Dr. L. L. Stubbs of the Burnley Gardens, E. I., Victoria, Australia; (3) *"Itersonilia pyriformis,"* isolated from dead leaves of *Acer macrophyllum* by Dr. George Nyland, culture obtained from the Centraalbureau voor Schimmelcultures, Baarn, Netherlands; (4) "Canadian isolate" from sunflower, *Helianthus annuus* L., infected with *Puccinia helianthi* Schw., by Dr. S. K. Sackston of the Univ. of Manitoba, Winnipeg, Manitoba; (5) "Massachusetts isolate," isolated from parsnips showing canker by Dr. E. F. Guba of the Waltham Field Station, Waltham, Massachusetts. The isolates were grown on 2 percent malt extract agar for 4 days at 21° C. Small cubes of agar and mycelium were cut from these cultures and mounted in Shear's mounting fluid (Chupp, **1940**). Fifty ballistospores of each isolate were measured. Chlamydospores of each isolate producing them were also measured. Other characteristics of the five isolates and of a sixth one, "saprophytic New York isolate," were studied. The last mentioned was from healthy parsnip leaves collected at Ithaca, New York. The ability of the isolates to form monocaryotic conidia was determined by flooding petri-dish cultures of each growing on "Difco" yeast-beef-extract agar with approximately 15 ml of sterile-distilled water. The cytology of the New York isolate was investigated by using an aceto-orcein smear technique suggested by Dr. L. S. Olive.

Pathogenicity: The pathogenicity of the isolates which produced ballistospores was determined by spraying a suspension of ballistospores on the foliage of parsnip seedlings growing in a greenhouse. After being covered with polyethylene bags to prevent cross inoculation, the

seedlings were placed in a moist chamber and incubated for 48 hours at $20 \pm 2°$ C and then returned to the greenhouse. As soon as leafspots appeared on the plants the pathogen was re-isolated by suspending the infected leaves over malt agar.

A micro-manipulator was utilized to obtain 4 single, monocaryotic conidial clones from each of the dicaryotic isolates which produced monocaryotic conidia. Suspensions of monocaryotic conidia of each clone were combined in all possible combinations of two. The resulting combinations of monocaryotic clones were atomized on parsnip seedlings and the seedlings were covered with polyethylene bags and incubated as described in the preceding paragraph. This experiment was repeated using monocaryotic ballistospores produced by the single monocaryotic conidial clones. The fungus was re-isolated from the infected leaves and its nuclear condition determined in stained preparations. The formation of the dicaryon from the monocaryon was also attempted in culture. The 4 monocaryotic clones from each of the dicaryotic isolates were transferred to malt agar in petri dishes. Five monocaryotic clones were placed on the agar in each petri dish until all possible combinations were obtained. After the developing colonies made contact with adjacent colonies, cubes were cut from the centers of the petri dishes at the point of convergence. The nuclear condition of the isolate in these cubes was determined.

EXPERIMENTAL RESULTS

Mycelium: The dicaryophase mycelium of the isolates was provided with clamp connections on each cell, while in the monocaryophase clamp connections were absent, or at most false clamps were sometimes observed. Considerable variation in the amount of aerial mycelium produced by each isolate, and by the same isolate grown under different conditions, was noted. Nevertheless, *I. pyriformis* consistently showed more aerial mycelium in culture than did the others.

Sporogenous cells: In both dicaryophase and monocaryophase, terminal hyphal cells which are slightly swollen may give rise to a tapering sporophore, upon which the ballistospore is borne. Occasionally a ballistospore (either monocaryophase or dicaryophase) may function directly as a sporogenous cell, giving rise to a sporophore and a secondary ballistospore.

In both dicaryophase and monocaryophase the ballistospores are lunate-reniform, and forcibly discharged by the water-drop mechanism typical of basidiomycetous sterigmata and basidiospores. Ballistospores germinate either to form a mycelium or a secondary ballistospore.

Ballistospores: The size of the ballistospores as reported in the literature and as measured for 5 dicaryophase isolates is given in TABLE I. On the basis of these data, ballistospore size does not seem to be a reliable criterion for the separation of taxa among the isolates studied.

Conidia: In dicaryophase, hyaline, obovoid, terminal cells which may represent conidia are formed. They are not discharged, however, nor have they been observed to germinate. In monocaryophase, conidia are frequent, filiform, subfusoid or falcate and reproduce by budding in a yeast-like fashion. When the monocaryophase is initiated by flooding a dicaryophase culture on the appropriate medium, the monocaryophase which can be isolated is almost wholly composed of such budding conidia. Only after some time, or on transfer to another medium, does the "conidial culture" become mycelial (monocaryophase).

TABLE I

SIZE OF BALLISTOSPORES OF MEMBERS OF ITERSONILIA AS REPORTED IN THE LITERATURE AND AS MEASURED DURING THE PRESENT INVESTIGATION

Isolate	Reference	Length (microns)		Width (microns)	
		Average	Range	Average	Range
I. pyriformis	Nyland (**1950a**)	15.6	11.7–19.5	7.3	6.5– 9.1
I. perplexans	Derx (**1948**)		14–15		8–10
"Myzel II"	Stempell (**1935**)	12.45	10–14	7.02	5– 9
I. perplexans	Olive (**1952**)		12.2–18.0		7.6–10.6
New York		13.45±1.54	9.8–16.4	7.64±1.05	6.5– 9.8
Massachusetts		13.25±1.47	9.8–16.4	7.77± .98	6.5– 9.8
Australian		11.61±1.21	9.8–13.4	7.70± .56	5.6– 8.8
I. pyriformis		12.92±1.18	9.8–15.7	7.08±1.18	3.9– 9.8
Canadian		10.10± .72	8.2–12.1	5.94± .92	3.9– 9.2

Chlamydospores: In both dicaryophase and monocaryophase chlamydospore-like structures may be formed, usually borne terminally, but often in clusters. In the dicaryophase a clamp connection is present at the base, but this is lacking in monocaryophase chlamydospores. The wall of the chlamydospore is slightly to greatly thickened, and nearly hyaline to golden brown. (The structures referred to by Nyland (**1950a**) as "chlamydospores" in *I. pyriformis* are what we term sporogenous cells.) Fusion of the nuclei in dicaryophase chlamydospores has not been shown. Measurements of the dicaryophase chlamydospores of our isolates are given in TABLE II. The production of chlamydospores by the isolates studied varied from none, by *I. pyriformis*, the Canadian isolate and the saprophytic New York isolate, to an abundance of large clusters of thick-walled, brown chlamydospores

by the Australian isolate. The New York and the Massachusetts isolates were intermediate, since they produced fewer chlamydospores with thinner walls and less intense pigmentation than those of the Australian isolate.

Pathogenicity on parsnip: All the isolates originally obtained from diseased parsnips as well as the Canadian isolate from sunflower produced leafspot symptoms on parsnip seedlings and were re-isolated. *I. pyriformis* and the saprophytic New York isolate, at the same spore concentration, produced no symptoms. They could not be re-isolated even from areas of the leaf that were necrotic because of mechanical injury.

Production of monocaryotic conidia: The ability of the isolates to produce monocaryotic conidia varied greatly. The New York isolate at first appeared to lack the ability to produce monocaryotic conidia, but later it was found that they are produced in small numbers. The isolate of *I. pyriformis* apparently is unable to produce monocaryotic conidia, but occasional structures which may have been monocaryotic conidia were seen in flooded cultures. If monocaryotic conidia are produced by the isolate of *I. pyriformis* studied, they are extremely rare, and it is impossible to detect them with certainty by the methods used. The other 5 isolates studied all produced monocaryotic conidia in relative abundance.

TABLE II

THE AVERAGE SIZE OF 50 CHLAMYDOSPORES OF ITERSONILIA PERPLEXANS ISOLATED FROM PARSNIP

Isolate	Length in μ	Width in μ
Australian	10.82 ± 1.64	9.58 ± 1.15
Massachusetts	12.27 ± 1.21	11.02 ± 1.21
New York	11.51 ± 1.15	10.20 ± .92

Cytology: The cytology of the New York isolate conformed to the findings of Olive (**1952**). None of the seedlings atomized with suspensions of monocaryotic conidia (single or mixed clones) developed any symptoms. All plants inoculated with monocaryotic ballistospores developed leafspot symptoms very similar to those on plants inoculated with dicaryotic ballistospores. When the fungus isolated from leaf infections was examined, however, it was monocaryotic. The monocaryon also failed to produce the dicaryon in pure culture.

DISCUSSION

Species of Itersonilia: All the isolates pathogenic on parsnips appear to represent a single taxon. All except the Canadian isolate produced both chlamydospores and monocaryotic conidia (TABLE III).

The absence of chlamydospores from the Canadian isolate is not considered significant, since the frequency of this structure varies among the other isolates, and the other characteristics of the Canadian isolate indicate that it is not a distinct species. If the pathogenic isolates are considered to represent a single taxon, then the difference in ballistospore size of *I. pyriformis* and *I. perplexans* cannot be considered significant, since it is well within the range of variation between pathogenic isolates. Consequently, the amount of aerial mycelium, a characteristic of doubtful taxonomic value, and the apparent inability to form monocaryotic conidia

TABLE III

PRESENCE (+) OR ABSENCE (−) OF CHARACTERISTICS OF SIX ISOLATES OF ITERSONILIA PERPLEXANS

Isolate	Chlamydospores	Monocaryotic conidia	Pathogenicity to *Pastinaca sativa*
New York	++[a]	+	+
Australian	+++	+++	+
I. pyriformis	−	−	−
Canadian	−	++	+
Saprophytic New York	−	++	−
Massachusetts	++	++	+

[a] The number of + signs indicates the relative frequency of the structure.

under the cultural methods employed in the present investigation remain the only means of separating *I. pyriformis* from *I. perplexans.* The authors agree with Tubaki (**1952b**) that these should be considered synonymous.

The genus Itersonilia: As originally defined *Itersonilia* is characterized by the possession of a dicaryotic mycelium provided with clamp connections; the production of binucleate, lunate-reniform ballistospores; and the absence of budding cells in culture. Only later were certain isolates found to produce chlamydospores.

The genus Tilletiopsis: Tilletiopsis as described by Derx (**1948**) is characterized by the possession of a monocaryotic mycelium without clamp connections; the production of uninucleate, falcate ballistospores; and the occurrence of a yeast-phase at the early stage of colony formation. Later, this genus also was shown to form chlamydospores. The

discovery of the monocaryophase of *Itersonilia* now throws some doubt upon the distinction between these 2 genera, since the *Itersonilia* monocaryon is devoid of clamp connections (though false clamps are sometimes formed) and a definite yeast-phase is present when the monocaryon is first formed. It is only in the shape of the ballistospores, falcate in *Tilletiopsis,* lunate-reniform in monocaryophase *Itersonilia,* that a distinction can now be drawn. The constancy of this single character has not been sufficiently investigated. The authors believe that these 2 genera should be merged and propose to use the name *Itersonilia* for the combined genus.

The genus Sporidiobolus: A third genus which must be considered is *Sporidiobolus* Nyland (**1950a**), characterized by the possession of a dicaryotic mycelium provided with clamp connections; the production of uninucleate, lunate-reniform ballistospores; and the occurrence of a yeast-phase of uninucleate (rarely binucleate) budding cells and golden-brown chlamydospores. *Sporidiobolus* appears to differ from *Itersonilia* primarily in the fact that nuclear fusion occurs in the chlamydospore of *Sporidiobolus* (Nyland, **1948**, **1950a**). If, however, the chlamydospore is initially uninucleate, and receives a second nucleus "through the clamp-connection on the stalk" as Nyland (**1948**) reported, this would represent a major distinction between the 2 genera. Nuclear behavior such as Nyland (**1948**, **1950a**) reported in *Sporidiobolus* is so anomalous, however, that it is difficult to accept these reports without additional confirmation by other workers.

Possible relationships of Sporobolomycetaceae with Tremellales and Ustilaginales: The taxonomic position of the Sporobolomycetaceae remains somewhat doubtful. These fungi appear to be members of the Fungi Imperfecti (Martin, **1941**). They are presumably closely allied to the Basidiomycetes, since all form ballistospores typical of the shot spore of the Basidiomycetes and since typical clamp connections are formed by some. Bessey (**1950**) included the family in the Ascomycetes, in the order Endomycetales, but admitted that their relationships are probably with the Basidiomycetes.

Martin (**1952**) included the family provisionally in the Tremellales (*sensu lato*), despite the lack of true basidia, and Olive (**1952**) suggested that *Itersonilia* at least may have originated from a tremellaceous ancestor. The cultural study of a species of *Dacrymyces* by Bulat (**1953**) is particularly significant, showing the strong likelihood that at least some of the Sporobolomycetaceae may represent "conidial" Dacrymycetaceae. The consistent appearance of a nonpigmented, *Tilletiopsis-*

like variant in Bulat's cultures deserves special attention and additional study.

In attempting to find possible relatives of *Itersonilia*, however, one is constantly drawn to the now impressive literature on the conidial stages of the Ustilaginales, particularly in the genus *Entyloma*. That these fungi produce a conidial stage has been demonstrated by many workers including Ward (**1887**), Buller (**1933**), Hanna (**1938**), Stempell (**1935**), Nyland (**1950b**), Brady (**1953**), and Grouet (**1954**). Liro (**1938**), however, concluded that the question of the formation of a conidial stage in *Entyloma* is not settled and proposed the interesting hypothesis that the conidial fungi reported as imperfect states of *Entyloma* may represent parasites on the smuts, since their appearance is correlated with a retardation of brandspore formation.

Most authors have reported a conidial stage for *Entyloma* with uninucleate, falcate conidia, which are violently discharged by the waterdrop mechanism. Filiform conidia, not violently discharged, also have been reported as an additional conidial stage in many species (Hanna, **1938**). The species of *Entyloma* thus resemble *Tilletiopsis* in culture; some species of both genera form chlamydospores in culture (Nyland, **1950b**; Tubaki, **1952a**). The genus *Entylomella* v. Höhnel, for which a generic diagnosis has apparently never been provided, was proposed for the conidial stages of *Entyloma*, *Doassansia*, and other genera, but this genus has apparently not been accepted. The fact that *Entylomella* and *Tilletiopsis* have many characters in common suggests an interrelationship of *Tilletiopsis* with the "white smuts."

The observations of Stempell (**1935**) require special attention. In cultural experiments with *Entyloma ranunculi* (Bon.) Schröt. and *E. calendulae* (Oudem.) de Bary he found that both species were capable of producing a monocaryotic mycelium in culture and that this mycelium gave rise to typical, falcate, monocaryotic ballistospores, as well as monocaryotic chlamydospores of the same size and color as those of typical dicaryotic brandspores of the respective smuts on their host plants. In addition, Stempell observed what he termed the "Myzel II" stage of *E. calendulae*, which produced dicaryotic mycelium provided with clamp connections, lunate-reniform ballistospores which were dicaryotic, and dicaryotic chlamydospores similar to typical brandspores produced in the host (i.e., brown-walled). Unfortunately, Stempell did not carry out reinfection of the host plants, so that the identity of his ballistospore-producing isolates and the smut organisms may be questioned, as Liro (**1938**) pointed out.

Of the workers who have studied *Itersonilia*, Derx (**1948**), Nyland (**1950a**) and Sowell (**1954**) all suggested that Stempell's "Myzel II" was probably a species of *Itersonilia* rather than the true *Entyloma*. None of them stressed the similarity in pigmentation of the chlamydospores of *Itersonilia* to those of "Myzel II" and of *Entyloma*. Chlamydospores were first demonstrated in *Itersonilia* by Olive (**1952**), though Stempell (**1935**) illustrated chlamydospores in his "Myzel II." Correspondence between the senior author and Dr. Derx revealed that the type specimen of *I. perplexans* did not produce chlamydospores. "My cultures," wrote Dr. Derx, "only produced thin walled terminal or intercalary inflations as figured in my paper." Stempell observed 2 types of germination of "Myzel II" chlamydospores: (1) Germination, which is similar to the germination of *Sporidiobolus* reported by Nyland (**1948**), by the production of a normal, *Entyloma*-type basidium and spores, or (2) Atypical germination to form a secondary chlamydospore without a basal clamp at the end of the germ tube, or sometimes by production of a mycelium provided with clamp connections. The mycelium produced by germination of chlamydospores is strikingly similar to the dicaryotic mycelium produced by the parsnip pathogen. Stempell was unable to investigate the cytology of spores which germinated "normally," but in spores which germinate "atypically" he found no fusion of the nuclei. The "normal" type of germination has not yet been found by workers with *Itersonilia*, but appears to be what occurs in *Sporidiobolus*, if that is indeed distinct.

Brady (**1953**) confirmed the results of Stempell (**1935**) in demonstrating the presence of monocaryotic, falcate ("allantoid") conidia and dicaryotic, reniform-lunate ("half-moon-shaped") conidia in *Entyloma calendulae*. Even more significant, perhaps, was her discovery of reniform-lunate conidia which were binucleate in 4 additional species of *Entyloma* (though only falcate conidia were found in 2 other species). The pathogenicity of these conidia of *Entyloma* has apparently not been demonstrated, but the similarity of their germination and the formation of appressoria on contact with the leaf surface are very similar to that of the *Itersonilia perplexans* isolates from *Pastinaca sativa*.

Both *Itersonilia* and *Sporidiobolus* may be stages in the life-cycle of *Entyloma* spp. or may have evolved from *Entyloma*. *Tilletiopsis* may represent monocaryophase *Entyloma* or monocaryophase *Itersonilia* or may contain some elements derived from the Tremellales (Bulat, **1953**). In spite of the possibility of a relationship between *Itersonilia* and *Entyloma*, the authors believe that it is desirable to maintain the genus *Itersonilia* for these common, asexual fungi.

AN EMENDATION OF THE GENERIC DESCRIPTION OF ITERSONILIA

On the basis of our studies, the following emended description of *Itersonilia,* based primarily on *I. perplexans,* seems warranted.

ITERSONILIA Derx, Bull. Bot. Gard. Buitenzorg III **17**: 471. 1948, *emend.* (Holotype species (monotype): *I. perplexans* Derx.)
= ?*Entylomella* v. Höhnel, Oestrr. Bot. Zeits. **66**: 105. 1916, *nomen nudum.* (Lectotype species: *E. ficariae* (Berk.) v. Höhn., designated by Weese, Mitt. Bot. Inst. Techn. Hochsch. Wien **9**: 58. 1932.)
= ?*Tilletiopsis* Derx ex Derx, Bull. Bot. Gard. Buitenzorg III **17**: 471. 1948; = *Tilletiopsis* Derx, Ann. Mycol. **28**: 3. 1930, *nomen provis.* (Lectotype species: *T.* "sp. No. 4 Derx," designated by Derx (1948 *loc. cit.*) = ?*T. washingtonensis* Nyland.)
= ?*Sporidiobolus* Nyland, Mycologia **41**: 686. 1950. (Holotype species (monotype): *S. johnsonii* Nyland.)

DICARYOPHASE: *Mycelium* hyaline, composed of binucleate cells, clamp connections normally present on every cell, not forming yeast-like cells by budding; appressoria formed on contact with glass; usually giving rise to monocaryotic conidia on flooding. *Dicaryotic ballistospore* hyaline, lunate-reniform, borne on a sterigma on a sporogenous cell, discharged by the water-drop mechanism, on germination forming a dicaryotic mycelium or directly transformed into a sporogenous cell bearing a secondary dicaryotic ballistospore. *Dicaryotic conidium* hyaline, obovoid with a truncate base, not discharged, germination unknown. *Dicaryotic chlamydospore* present or absent, nearly hyaline to deep golden brown, thin to thick-walled, single or in terminal clusters on short lateral branches of the mycelium, rarely appearing to be intercalary, forming a dicaryotic mycelium on germination. *Caryogamy* apparently absent.

MONOCARYOPHASE: *Mycelium* hyaline, composed of uninucleate cells, incomplete clamp connections sometimes formed, not reverting to the yeast-phase of growth; appressoria unknown. *Monocaryotic ballistospore* hyaline, lunate-reniform, borne on a sterigma on a sporogenous cell, discharged by the water-drop mechanism, on germination forming a monocaryotic mycelium or directly transformed into a sporogenous cell bearing a secondary monocaryotic ballistospore. *Monocaryotic conidium* filiform, subfusoid, or falcate, formed on flooding of dicaryotic cultures, reproducing in a yeast-phase by budding similar monocaryotic conidia from one or both ends, at times producing a limited mycelium, particularly on transfer to another medium, at times transformed directly into a sporogenous cell bearing a monocaryotic ballistospore. *Monc-*

caryotic chlamydospore present or absent, like that of the dicaryophase but forming a monocaryotic mycelium on germination. *Re-establishment of the dicaryophase* from the monocaryophase not yet successfully accomplished.

SUMMARY

The genus *Itersonilia* is emended on the basis of variation in monocaryophase and dicaryophase cultures. Probable synonyms include two other genera of the Sporobolomycetaceae, *Tilletiopsis* and *Sporidiobolus*, and the proposed but invalid genus *Entylomella* (representing conidial states of *Entyloma* and other smut fungi). The isolates of *Itersonilia* responsible for leafspot and canker of parsnip, *Pastinaca sativa* L., in the United States are considered to represent *I. perplexans* Derx.

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GROWTH SUBSTANCES FOR POLYPORUS SCHWEINITZII [1]

WILLIAM J. ROBBINS AND ANNETTE HERVEY

(WITH 6 FIGURES)

In an earlier publication from this laboratory, Yusef (**6**) reported that the growth of *Polyporus schweinitzii* No. 86353 was markedly improved by the addition of small amounts of malt extract to a basal medium containing dextrose, vitamins and "vitamin free" casein hydrolysate. He suggested that unidentified growth-promoting substances for this fungus were present in malt extract. We have continued the investigation and have concluded that this isolate suffers from a partial deficiency for at least two unidentified growth substances.

EXPERIMENTAL

Culture Methods.—Unless otherwise stated, the fungus was grown in triplicate for two weeks at 25° C in 125 ml Erlenmeyer flasks containing 25 ml of medium. Dry weights were obtained by treating the mycelium with 70% alcohol, filtering into Gooch crucibles and drying at 100°. The basal medium contained mineral salts, dextrose and "vitamin free" casein hydrolysate (Nutritional Biochemicals), supplemented with vitamins and purine and pyrimidine bases.[2]

Assay.—Growth promotion was assayed as follows: Various amounts of the preparation assayed were added to the basal medium and the hydrion concentration adjusted to pH 4.5±. A net gain [3] in dry weight of mycelium of three cultures of 10 mg (3.3 mg per culture) was considered to be one dilution unit (du) of activity.

For example, a water extract (A) of beechwood sawdust contained 10.2 mg dry matter per g of wood extracted. The activity of the extract (FIG. 1) was 250 μg per du or 40 du per g of wood extracted.

A quantity (1445 g) of dry sawdust was refluxed for 4 hrs with 10 liters of freshly distilled chloroform. The chloroform was decanted

[1] The assistance of Mary Stebbins Womack is gratefully acknowledged.

[2] See reference (**4**) or (**5**) for composition of basal medium.

[3] Gain over growth in basal medium.

and refluxing repeated with 7 liters. The combined extracts were evaporated in the presence of water and filtered. The resulting extract contained 87.3 mg dry matter and its activity was 18 μg per du. The chloroform extract yielded, therefore, a total of approximately 5000 du of activity. On the basis of water extract (A) the total du for 1445 g of wood should be 57,800 du.

We concluded that substance(s) which promote the growth of *P. schweinitzii* are present in beechwood, that they are soluble in water and in chloroform, that the chloroform extract was many times more active per unit dry matter than a water extract, but the total activity in the chloroform extract was about 10 per cent of that in water extract (A).

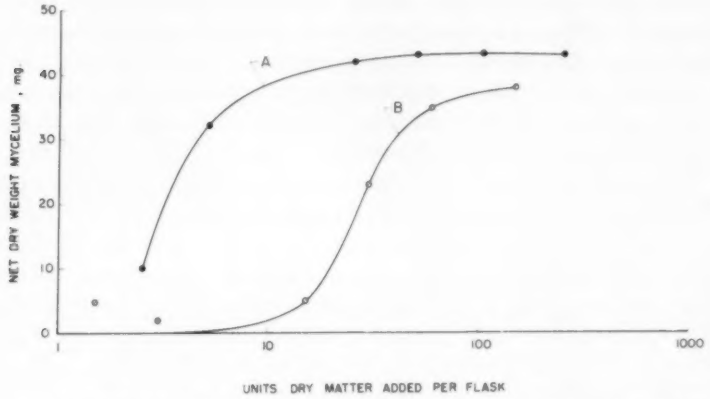

FIG. 1. Net dry weight of mycelium produced by *P. schweinitzii* in the basal medium supplemented by various amounts of aqueous extract (A), and a chloroform extract, (B) of wood. The unit of dry weight added per flask is 100 μg for the aqueous extract and 1 μg for the chloroform extract.

For ill-defined reasons, assay values varied considerably. For example, assays repeated on a concentrate (4–122–5) prepared from yeast ranged from 14 to 100 μg per du. A du for yeast extract frequently run as a control was usually 1.5 to 2.5 mg but ranged from 0.7 to 6 or 7 mg. In spite of the variability of the assay it was found useful in estimating the activity of various preparations.

Existence of unidentified growth substances.—Growth promotion by a natural material when added to the basal medium was taken as presumptive evidence for the existence for *P. schweinitzii* of unidentified growth substance(s). This assumption was substantiated for several natural

products by extracting and concentrating active material and by our failure to duplicate the growth promoting effects by modifying the basal medium or supplementing it with known compounds.

The following were added singly to the basal medium with negative results: sodium acetate, ferric tartrate, gibberellic acid and gibberellin A mixture, kindly supplied by Dr. Frank H. Stodola, Northern Regional Laboratories: glutathione, kinetin, methionine, shikimic acid, from Dr. Ulrich Weiss; DL-mevalonic acid as the N,N^1-dibenzyl ethylene diamine salt, arachadonic acid; linolenic acid, vaccenic acid, protogen (thioctic acid), pelargonic acid, (+) α-lipoic acid crystals and cholesterol. The last 8 compounds were supplied through the courtesy of Merck and Co.

A variety of supplements [4] kindly supplied by Dr. Seymour Hutner were added with negative results to the basal medium containing mineral salts, dextrose and the purine and pyrimidine bases but lacking casein hydrolysate and vitamins. No beneficial effects were noted when the Hutner supplements were used with Hy case or an amino acid mixture substituted for gelatine hydrolysate.

The amino-acid mixture (Hutner's #9) contained in mg per flask (25 ml medium) DL alanine, 10; L-arginine-l-glutamate, 15; DL-aspartic acid, 15; L-cystine ethyl ester HCl, 1; L-glutamic acid, 20; glycine, 12.5; L-histidine HCl, 10; L-isoleucine (Cal.) pure, 1.5; L-leucine (Cal.) pure, 1.5; L-lysine-l-glutamate 6.25; DL-methionine, 2.5; DL-phenylalanine, 1.5; L-proline, 2.5; DL-serine, 2.5; DL-threonine, 2.5; DL-tryptophane, 1.5; L-tyrosine ethylester HCl, 1.25; L-tyrosine, 0.5; DL-valine, 1.5; NH_4HCO_3, 2.5.

The action of the unidentified factors was not duplicated by varying the amount of minor elements or of casein hydrolysate or by substituting amino acids or inorganic nitrogen for casein hydrolysate.

Oleic acid: Yusef (**6**) found that the addition of oleic acid to his basal medium improved the growth of *P. schweinitzii*, but concluded that this substance did not account for the favorable effect of malt extract. In our experiments the addition of sodium oleate to our basal

[4] The following preparation was added in the amounts given in mg/flask: Gelatine hydrolysate, 100.0; L-tryptophane, 1.25; DL-methionine, 1.25; alkaline hydrolysate of yeast nucleic acid, 5.0; acid hydrolysate of DNA herring, 2.5; thiamine HCl, 0.025; nicotinic acid, 0.025; Ca pantothenate, 0.025; choline H_2 citrate, 0.375; Na riboflavin PO_4, 0.0025; pyridoxamine 2 HCl, 0.005; pyridoxal HCl, 0.005; inositol, 0.25; putrescine 2 HCl, 0.01; 1,4-diaminobutane, 0.0025; p-amino benzoic acid, 0.0025; p-hydroxy benzoic acid, 0.0025; B_{12}, 0.000025; biotin, 0.000125; dl thioctic acid, 0.001; citrovorum factor; 0.00005; folic acid, 0.001.

medium improved growth but was less effective than concentrates prepared from yeast.

Pelargonic aldehyde.—Fries (1) reported pelargonic aldehyde (nonanal) to be a growth substance for some wood-rotting fungi. Pelargonic aldehyde added to our basal medium improved the growth of *P. schweinitzii*. The effect was small compared to that induced by concentrates prepared from yeast. Pelargonic aldehyde is volatile; the factors we have investigated are not.

Partial deficiency.—*P. schweinitzii* grows slowly in the basal medium but in time produces a substantial amount of mycelium. For example, although growth in the basal medium amounted to 6 mg at the end of two weeks, at the end of four weeks it was 98 mg. Subcultures made from growth in the basal medium to the basal medium continued to grow. Although traces of the unidentified growth substances exist in the casein hydrolysate which is a constituent of the basal medium, the amount is too small to account for the growth obtained. We concluded that *P. schweinitzii* suffers from a partial deficiency for the unidentified growth substances, i.e., it synthesizes some but the amount is insufficient for the maximum growth which is possible when the substances in question are present in the culture medium.

Distribution of growth substances.—Unidentified growth substances effective on *P. schweinitzii* are widely distributed in natural products. Malt extract, yeast extract, tomato juice, coconut milk, casein, beech wood, cork, agar, and gelatine were found to promote the growth of the fungus and to contain one or both of the unidentified substances. Observations on the growth promoting activity of some of these natural products follows:

Malt: Malt extract had considerable growth promoting power (300 du or more per g), and preparations with high activity (1 du = 40 μg or less) were secured by extraction with ethyl acetate or a mixture of 1 part of ethanol and 9 parts of ethyl acetate.[5] Growth-promoting material was adsorbed from malt extract by Norit A from which it was eluted, at least in part, by ammoniacal acetone.

Wood: Beech wood contained growth-promoting material for *P. schweinitzii*. Extracts were prepared by autoclaving from 250 to 600 g of sawdust with 8 liters of distilled water. The supernatant liquid was concentrated to 1 liter and filtered. The extract of from 25 to 100 mg of wood (containing from 250 to 800 μg of dry matter) gave 1 du of

[5] For brevity, this mixture is referred to as alcohol-acetate.

activity. The maximum effect of wood extract rarely exceeded an increase of 40 mg dry weight of mycelium. Flattening of the growth curves as the amount of extract added was increased suggested a limiting factor (FIG. 1). Wood extract dried at 120° for 18 hrs retained its full growth-promoting power. Cold water or hot water extracts as well as those prepared by autoclaving were effective.

An extract prepared by refluxing sawdust with 10 per cent H_2SO_4 and removing the acid with $Ba(OH)_2$ had a greater growth-promoting power than water extracts. This may have resulted from more complete extraction of active material or because of its formation in the hydrolysis.

Preparations more active on a dry weight basis than water extracts were obtained by extracting sawdust in a Soxhlet extractor with ethyl acetate (1 du = 180 μg) or with $CHCl_3$ (1 du = 20 μg). The total activity per g of wood extracted with ethyl acetate equalled that obtained with water; with $CHCl_3$ it was 10 to 25 per cent. A liquid-liquid extraction (21 hrs) of a water extract with ethyl-ether removed a substantial amount of growth-promoting material and produced an active preparation (1 du = 60 μg).

Countercurrent distribution, using systems of water, ethyl ether, ethanol or water, ethyl acetate, ethanol indicated the presence in water extracts of wood of one substance which followed the organic phase. In the hydrolysate two substances appeared to be present, one more polar than the other. Considerable activity was adsorbed from a water extract of wood on Norit A and was partially eluted with ammoniacal acetone.

Tomato Juice: Campbell's tomato juice was filtered through cheese cloth and celite. The addition of 0.5 ml of the clear yellowish fluid per flask of basal medium increased growth by from 49 to 76 mg. Two ml were more effective than 0.5 ml but 5 ml were beyond the optimum. The juice from fresh tomatoes was active also. About $\frac{3}{4}$ of the activity remained in the aqueous phase when tomato juice was extracted three times with an equal volume of ethanol-acetate.

Growth-promoting material in tomato juice which had been concentrated to a brown gum at low (50°±) temperature was soluble in 95 per cent ethanol and in 95 per cent acetone.

In a 10-funnel countercurrent distribution of the alcohol soluble material against ethanol-acetate, most of the activity appeared in the aqueous phase and at the more polar end of the series (FIG. 2). In contrast to wood extract most of the activity of tomato juice was due to more polar material.

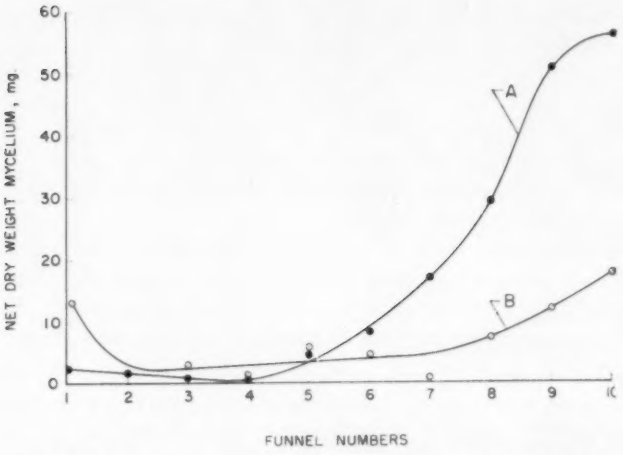

FIG. 2. Net dry weight of mycelium produced by *P. schweinitzii* in basal medium supplemented with unit volumes of aqueous phase (A) and of organic solvent phase (B) on a 10-funnel countercurrent distribution of an aqueous preparation of an ethanol extract of concentrated tomato juice against ethanol-ethyl acetate. Note activity is greatest in aqueous phase at 10 end of the series.

The activity of tomato juice was not destroyed by drying at 100° nor by refluxing in 10 per cent H_2SO_4 for 4 hrs.

A preparation containing mainly more polar material was shaken with 2 per cent Norit A for 2½ hrs. About 75 per cent of the activity was removed and about 15 per cent of the original activity was recovered by eluting the Norit A with 95 per cent alcohol.

Agar: Agar was found to contain substances which promote the growth of *P. schweinitzii*. Growth in Petri dishes containing the basal medium solidified with agar was observed to be substantially better than in the liquid basal medium. The possibility that this difference was the result of better aeration on the agar medium was eliminated by comparing growth in liquid medium with that in flasks containing a layer of agar covered with the liquid medium. In both instances the fungus grew below the surface of the liquid, but growth in the flask containing agar was much superior to that in the liquid medium with no agar (TABLE I). An extract obtained by shaking Difco agar with distilled water promoted growth when added to the basal liquid medium.

Agar was dissolved in water and precipitated with alcohol. The supernatant freed of alcohol was beneficial and growth in Petri dishes containing the basal medium solidified with the precipitated agar was

less than that when the original agar was used. Growth in a purified agar [6] was less than on the unpurified agar.

Gelatine: Eastman purified calfskin gelatine promoted the growth of *P. schweinitzii* (TABLE I). Gelatine was dissolved in water and precipitated with 95 per cent ethanol. In Petri dishes containing the basal medium plus 15 per cent gelatine, growth in diameter and the dry weight of mycelium were considerably greater on the original gelatine than on the precipitated gelatine.

The supernatant obtained in precipitating the gelatine was freed of alcohol and added to the basal medium. The extract of 4.3 g of gelatine containing 20.4 mg of dry matter per flask produced 26 mg of mycelium as compared to 4 mg in the basal medium with no extract.

TABLE I

DRY WEIGHT OF P. SCHWEINITZII GROWN TWO WEEKS IN 250 ML ERLENMEYER FLASKS CONTAINING: (A) 50 ML OF 2 PER CENT AGAR OR 30 PER CENT GELATINE COVERED BY 50 ML OF BASAL MEDIUM; (B) 2 PER CENT AGAR OR 30 PER CENT GELATINE IN 50 ML BASAL MEDIUM

Addition to basal medium	Dry wt. (mg) mycelium per 3 flasks	
	A	B
Purified Difco agar	59	74
Eimer and Amend flake agar	44	46
Difco agar	63	136
Gelatine	151	155
None	9	9

Gelatine was hydrolyzed by refluxing with 7 per cent H_2SO_4 and the acid removed with $Ba(OH)_2$. The clear brown solution was extracted with ethanol-acetate. The extract and aqueous phase were freed of organic solvents. Added to the basal medium the hydrolysate and aqueous phase were toxic in the amounts used. Growth with the ethanol-acetate extract added at the rate of 2.5 g of original gelatine (9 mg dry matter) per flask was 57 mg as compared to 6 mg in the basal medium with no extract.

Cork: A water extract of cork added to the basal medium promoted growth. A new cork weighing 2.5 g was boiled 1 hr in distilled water. For this extract, 1 du was 100 μg and 1700 μg per flask induced a net gain of 43 mg dry weight of mycelium.

Casein: Nitrogen was furnished in the basal medium as casein hy-

[6] Difco agar was percolated with several volumes of 5 per cent aqueous pyridine followed by 1 per cent hydrochloric acid. The agar was then neutralized with calcium hydroxide, washed free of excess calcium, treated with 95 per cent ethanol and dried at low temperature.

drolysate prepared by adding excess $CaCO_3$ to "vitamin-free" casein hydrolysate and filtering. The neutralized preparation was added at the rate of 50 mg of original hydrolysate per flask (2 mg per ml). No difference in growth was noted when the amount of the casein hydrolysate was varied from 25 to 200 mg per flask. However, the presence of a small amount of growth-promoting material in the "vitamin-free" hydrolysate was demonstrated by extraction with ethanol-acetate. The extract promoted growth and contained 3 du per g of the original hydrolysate.

Eastman casein also contained small amounts of growth-promoting material which was extracted with chloroform or with ammoniacal acetone. The maximum activity obtained by extraction with chloroform in a Soxhlet extractor amounted to 4 du per g of casein. The dry matter per du in the chloroform extract was 30 μg.

A sample of "vitamin test" casein from Nutritional Biochemicals was extracted with boiling chloroform and with ammoniacal acetone. These extracts contained 1 du per g of casein extracted. However, a hydrolysate of this casein contained from 10 to 14 du per g of casein and an extract of the hydrolysate with ethanol-acetate contained 5 du per g of casein. A countercurrent distribution of the alcohol-acetate extract demonstrated the presence of both the more polar and less polar factors.

A hydrolysate of crude casein prepared by Dr. Frederick Kavanagh was highly active. It contained 125 du per g of casein and the addition of 100 mg per flask produced a net increase of 180 mg of mycelium.

Yeast: The results with malt, wood, casein, cork, tomato juice, agar and gelatine led us to assume at least two unidentified growth-promoting substances one more polar than the other, both soluble in organic solvents, adsorbed on charcoal and thermostable. Further investigation with yeast extract confirmed and extended this assumption.

Growth-promoting material in yeast extract was soluble in water, ethanol, ethyl acetate, ethyl ether and chloroform (FIG. 3). About 40 per cent of the activity of the aqueous solution was removed by ethyl acetate, 30 per cent with ethyl ether and 15 per cent with chloroform. On the basis of dry matter added per flask, the chloroform extract was the most active (1 du = 7 μg) followed by ethyl ether (1 du = 50 μg), ethyl acetate (120 μg) and the aqueous extract (2500 μg).

In countercurrent distribution in a 50 tube Craig apparatus of active concentrates against ethyl acetate or ethyl ether at pH 7.0 activity was mainly at the ends of the distribution series indicating at least two growth-promoting substances, one more polar than the other (FIG. 4).

As dry yeast was extracted with ethyl acetate in a Soxhlet extractor, a whitish precipitate formed in the ethyl acetate solution. The growth-promoting activity of the supernatant was greater (1 du = 104 μg, total activity 40,000 du) than that of the precipitate (1 du = 1800 μg, total activity 800 du). The slope of the curve for increase in growth of mycelium plotted against dry matter of precipitate added per flask was steeper than that for the supernatant (FIG. 5). Countercurrent distribution demonstrated that the less polar factor predominated in the supernatant, the more polar in the precipitate.

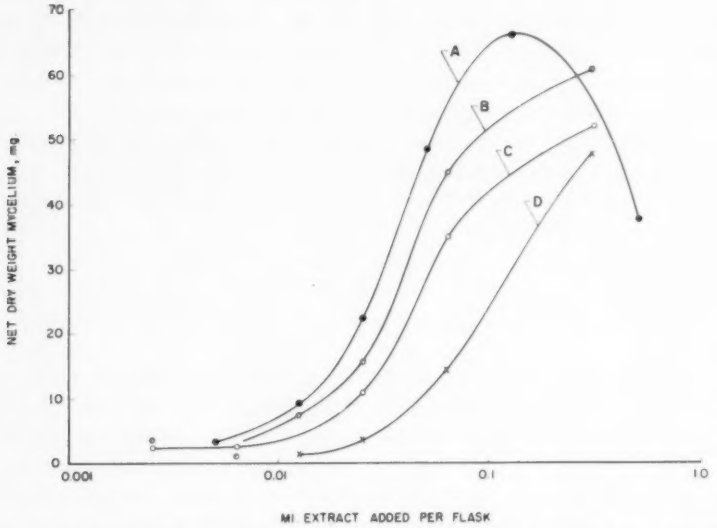

FIG. 3. Net dry weight of mycelium produced by *P. schweinitzii* in basal solution supplemented with various amounts of (A), yeast extract; (B) ethyl acetate extract of (A); (C), ethyl ether extract of (A); (D), chloroform extract of (A). 1 ml of (A) contained 200 mg dry matter; of (B) 7.95 mg; of (C) 3.0 mg and of (D), 0.15 mg.

The more polar material was acidic, the less polar "neutral." This conclusion followed because at pH 2 or 3 most of the activity of both the more polar and less polar substance moved from a M/20 phosphate buffer into ethyl acetate; at pH 7.0 the less polar moved into the ethyl acetate but most of the more polar remained in the aqueous phase.

Both substances were thermostable and resisted drying and heating at 100°.

Nitrogen: Casein hydrolysate or a mixture of amino acids was a satisfactory source of nitrogen for this fungus in the basal medium,

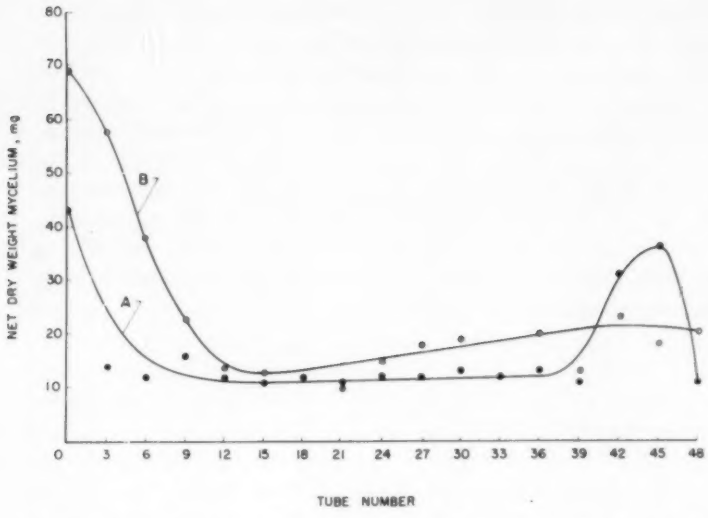

FIG. 4. Net dry weight of mycelium produced by *P. schweinitzii* in basal solution supplemented with a unit volume of aqueous phase (B) and ether phase (A) of a 50 tube Craig apparatus countercurrent distribution of an active concentrate from yeast at pH 7.0 against ethyl ether. Note growth-promoting activity concentrated at both ends of distribution.

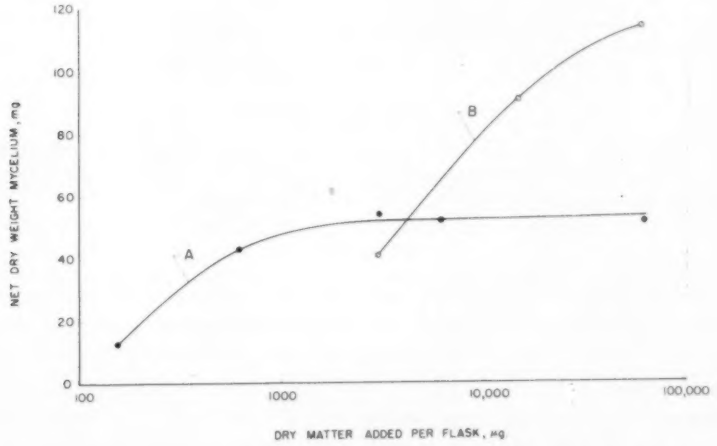

FIG. 5. Growth of *P. schweinitzii* in basal medium supplemented with various amounts of ethyl acetate soluble material (A) from Soxhlet extraction of dry yeast extract and precipitate (B) which formed in ethyl acetate during extraction.

but NH_4NO_3, $(NH_4)_2SO_4$ or NH_4 tartrate was not. Neither of the unidentified growth substances served as a source of nitrogen. Growth in the basal medium with casein hydrolysate replaced by up to 1000 μg per flask of a concentrate of the less polar (4–112–1) or more polar (4–122–5) factors was little or no better than in the basal medium with no nitrogen. However, the addition of 250 or 1000 μg of the concentrate of the more polar factor per flask was growth promoting with NH_4NO_3 as the nitrogen source (FIG. 6). In this experiment, 1 du of the concentrate was 44 μg with casein hydrolysate and 250 μg with NH_4NO_3. Similar results were obtained with the concentrate of the less polar factor.

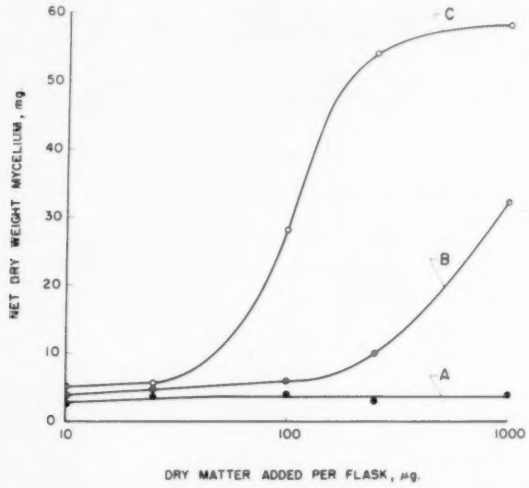

FIG. 6. Dry weight of *P. schweinitzii* with various amounts of concentrate (4–122–5) of more polar growth substance in presence of various nitrogen sources. (A), no nitrogen; (B), NH_4NO_3; (C), casein hydrolysate.

DISCUSSION

From our investigations we conclude that *P. schweinitzii* suffers from a partial deficiency for at least two unidentified growth-promoting substances. Both are soluble in organic solvents, adsorbed on charcoal and thermostable. One is "neutral" and less polar; the other acidic and more polar. They differ also in their effect on growth. Growth curves at the end of two weeks in a basal medium with additions of concentrates of the more polar (acidic) factor have a steeper slope and a greater maximum than those obtained with the less polar ("neutral")

factor. Both are highly active. Our best preparations measurably improved growth at less than one microgram per ml.

Oleic acid and pelargonic aldehyde promote the growth of *P. schweinitzii* to some degree but are not identical with the substances under study. The unidentified factors may, however, be related compounds.

That the substances may be involved in nitrogen metabolism is suggested by their effect on growth with nitrogen supplied as inorganic nitrogen.

How, generally, do fungi which fail to grow or grow slowly (**2**) on a basal medium respond to these factors (**4**)? Preliminary results (**5**) indicate that the growth of *Poria ambigua* is promoted by the substances under investigation. On the other hand, although the addition of natural products to our basal medium favors the growth of *Morchella esculenta* and *M. crassipes*, especially in acid medium (**3**), the material concerned is not adsorbed on charcoal but is present in the filtrate and is not identical with the unidentified factors which favor the growth of *P. schweinitzii*.

SUMMARY

Polyporus schweinitzii suffers from a partial deficiency for at least two unidentified growth-promoting substances which are widely distributed in natural products. Both are soluble in organic solvents, adsorbed in charcoal and thermostable. One is "neutral" and less polar; the other acidic and more polar. Concentrates producing a measurable increase in growth at less than 1 μg per ml were prepared. The substances may be involved in nitrogen metabolism.

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NEW YORK, NEW YORK

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NOTES AND BRIEF ARTICLES

Unusual Fruiting of Cordyceps militaris

The occurrence of *Cordyceps militaris* (Fr.) Link in epizootic proportions is unusual. Upon two occasions, July 30, 1958, and August 23, 1959, Dr. James Z. Gailun of West Hartford, Connecticut, has found over two hundred stromata on the pupae of a population of *Anisota stigma* Fab. (family Citheroniidae). Both collections were made at the same locality in Hurd State Park, Middle Haddam, Connecticut. Dr. Marian E. Smith, Department of Entomology and Plant Pathology, University of Massachusetts, kindly has determined the host.—Howard E. Bigelow, Department of Botany, University of Massachusetts, Amherst, Mass.

Rare Fungi Collected in Florida

Two fungi which apparently have been rarely collected have been found in the northern portion of Florida. The author is at present working on an environmental study of the Blastocladiales, Leptomitales, and Monoblepharidales which occur in the numerous "sinks" in this region (NSF Grant #9571). A fungus resembling *Blastocladia rostrata* Minden has been found twice. One isolate was recovered from an apple submerged in a drainage canal from a cypress swamp in western Leon County. The other was removed from an apple submerged in an unnamed sink in Wakulla County. Water temperature was 21° C in both cases. All key characteristics and measurements fitted the description but resting sporangia were not noted. The fungus failed to grow in the laboratory either on synthetic media or on apples. Dr. Leland Shanor reports (personal communication) that he found this fungus once in Louisiana.

The second fungus *Apodachyla minima* Coker & Leitner was isolated once from twigs of dogwood and water oak. The twigs had been suspended in a sink (Little Natural Bridge, Leon County) for four weeks at 21° C and then kept at 15° for two weeks in the laboratory. The fungus grew readily for several months on hemp seeds but has now perished. We are attempting to recollect this species.—A. W. Ziegler, Department of Biological Sciences, Florida State University, Tallahassee, Florida.

A NOTE ON THE OCCURRENCE OF PEZIZA OSTRACODERMA [1]

In April of 1959 and again in April and May, 1961, an interesting imperfect fungus was isolated in pure culture from mycelial masses on sterilized soil and peat-perlite mixtures in flats and clay pots in the plant pathology greenhouses of The Pennsylvania State University. The fungus could not be assigned to any form genus using the currently available general taxonomic treatments of the Deuteromycetes. It seemed, however, to be near the genera *Botrytis* and *Rhinotrichum*.

A search of the literature revealed that the conidial fungus was similar to that reported by Schneider (3) and Wolf (4) as imperfect states of apothecial fungi. In mid-May, 1961, umber brown apothecia were found developing on the flats which had previously borne the conidial state. They were identified as *Plicaria fulva* Schneider (3). Ascospore shootings were obtained from a number of the apothecia by fastening them on the inside of the upper lid of a petri dish. The ascospores germinated readily on malt extract agar and yielded pure cultures of a fungus similar to the conidial fungus previously found.

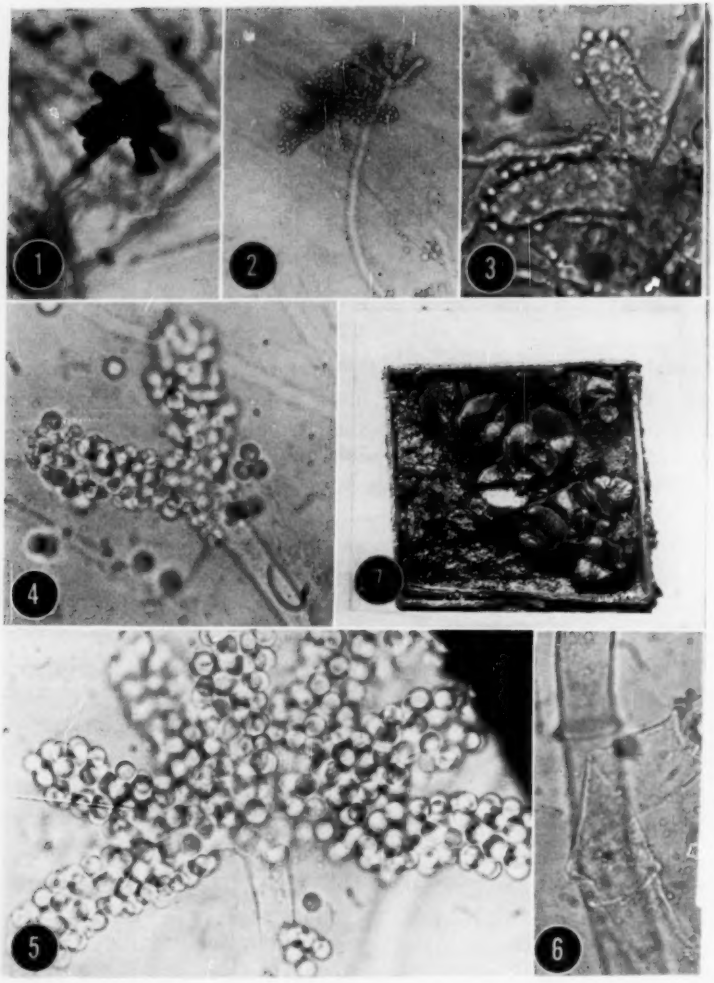
Specimens and photographs of the conidial state and the apothecia were sent to Dr. R. P. Korf, Cornell University. He kindly verified the identification of the fungus as *Plicaria fulva* Schneider. However, he indicated that the most suitable name for the fungus is *Peziza ostracoderma* Korf (1). The imperfect state belongs to the genus *Ostracoderma* Fr. (FIGS. 1–5).

At Dr. Korf's suggestion, specimens and photographs were also sent to Dr. G. L. Hennebert, Postdoctorate Research Fellow in Mycology at the Canada Department of Agriculture, Ottawa. He also verified the identification using the type specimen from R. Schneider.

P. ostracoderma has been found developing most abundantly on steamed soil in flats containing "plant bands" (FIG. 7) of treated paper or wood. The thick mycelial mass is almost impervious to water and plants growing in flats with thick coverings of the mycelium are often retarded in growth.

Since this fungus may be common in other greenhouses and be encountered by other plant pathologists and mycologists, and since the illustrations of the fungus are in European literature (2, 3), this note and illustrations are presented as an aid to identification of future collections.

[1] Contribution No. 285 from the Department of Botany and Plant Pathology, Pennsylvania Agricultural Experiment Station. Authorized for publication August 22, 1961, as paper No. 2592 in the Journal Series of the Pa. Ag. Exp. Station.



FIGS. 1–7. *Peziza ostracoderma.* 1. Conidiophore. 2. Young conidiophores. 3. Early stage in conidial formation, showing the sterigma upon which only one conidium develops. 4. A somewhat later stage in development of a conidiophore which has branched only once. 5. Numerous fertile heads at the end of a conidiophore. 6. Mature conidiophore showing ridges at the septa. 7. Mature apothecia.

The conidia form abundantly on sterilized soil and on malt extract agar, appearing as a yellow-cinnamon mat. The measurements of the conidia and conidiophores of the isolated fungus agree with those given by Schneider (3), FIG. 5. The matured conidiophores are coarse and possess unique and characteristic ridges at the septa, FIG. 6. Apothecia somewhat larger (up to 15 mm diameter) than those reported by Schneider (3) were found, FIG. 7. The ascospores measured 6–7.8 × 12–14.4 μ.—CHARLES L. FERGUS, Pennsylvania State University.

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A COPRINUS GROWING IN AN AUTOMOBILE

The writer found a polypore growing on a wooden strut of a station-wagon a number of years ago and has heard of similar findings by others, but to find a mushroom growing in a car was so odd that it is reported here.

In July, 1959, an acquaintance purchased in Connecticut a new car just imported from France. In order to protect the upholstery he covered the seats and paneling of the doors with a tightly fitting vinyl covering.

In July of 1960 he asked me to look at some kind of mold growing under the covering on the door on the driver's side. His description was vaguely suggestive of a *Coprinus,* and the growth on the door did prove to be sporophores of a member of this genus. It appeared that the mycelium had grown first in a thin layer of plywood under the cloth lining the door and then had grown into the cloth where it began to produce fruiting-bodies under the vinyl covering. This vinyl had formed a tight seal and helped make conditions suitable for growth of the fungus.

Transfers of tissue from the stem of young sporophores quickly grew on potato-dextrose-agar plus coconut milk. Fruiting-bodies soon formed when the fungus was grown in 300 ml Erlenmeyer flasks on 75 ml of our modification of Asheshov's A58 medium (1). (The composition of our modification is Heinz Baby Oatmeal Food 20 g, Tomato Paste (Italian Style) 20 g, Agar 18 g, tap water 1 liter.) The sporophores fitted the description of *Coprinus lagopus* as given by Buller (2) except that the spores of our specimens measured 8.5–10 × 6–6.5 μ whereas his description states ". . . 15–16.5 × 8–9 μ in large fruit-bodies, slightly smaller in dwarfs."

It was hoped that single-spore cultures of this isolate could be paired with single-spore cultures derived from North American and European strains in order to have more evidence as to the likeliest source of our isolate, but to date the strains obtained either have failed to produce sporophores or the sporophores have not looked like ours. We can only guess that probably the *Coprinus* established itself on or in the plywood before it was used in construction of the car.—JOHN B. ROUTIEN AND SHIRLEY SIMONZI, Fermentation Research, Medical Research Laboratories, Chas. Pfizer & Co., Inc., Groton, Connecticut.

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1. **Asheshov, I. N., F. Strelitz, and E. A. Hall.** 1952. Phagolessin A58: a new antibiotic active against bacterial viruses. Antibiotics and Chemotherapy **2** (7): 366–374.

2. **Buller, A. H. R.** 1924. Researches on Fungi, Vol. 3.

VOLUME LII—CORRECTIONS

page 639, line 7: change "2573" to "2537."

page 640, line 4: change "germinating after 60 minutes in 95 to 100 per cent of the exposed samples" to "germinating 95 to 100 per cent after 60 minutes exposure."

page 640, line 7: change "2573" to "2537."

page 641, line 7: change "2573" to "2537."

FINE STRUCTURE OF THIELAVIA SEPEDONIUM

Among many fungi isolated from soils from North and South America a species was found that had some interesting characters. It is a variable fungus, freely sectoring with some of the sectors producing ascocarps that darken the sector. Single spore cultures of the dark ascospores produce the *Sepedonium* stage. The colony color varies with the isolate from yellow through white to gray. The fungus is homothallic and the perfect stage is a *Thielavia*.

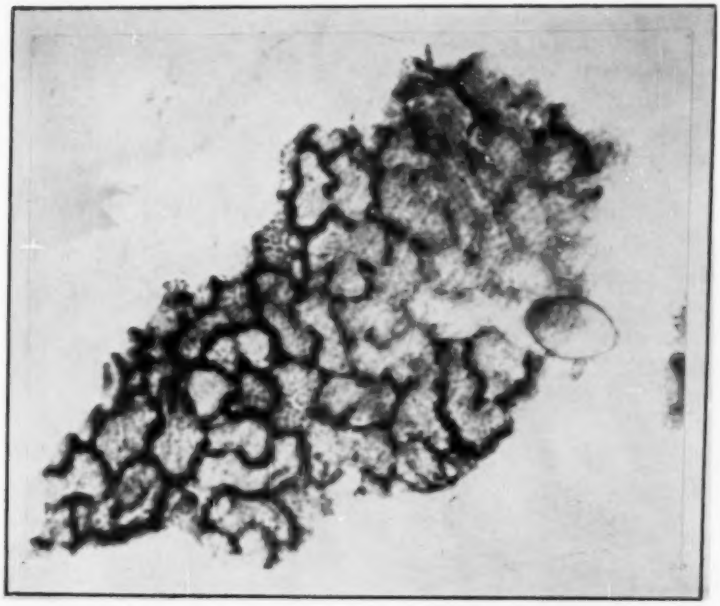

FIG. 1. *Thielavia sepedonium*, photomicrograph of fragment of ascocarp wall.

Emmons (1) described the organism and the interrelation of *Sepedonium* and *Thielavia*. It is thought to be the only *Thielavia* with this relationship, though Dade (2) described *Thielavia setosa* that has aleurispores. As the asci are evanescent, it was, at one time, identified as a *Coniothyrium*.

The ascocarps are interestingly sculptured and appear to have ridges surrounding small pitted areas (FIG. 1).

While I was studying other material with the electron microscope, ascocarps and conidia of this fungus were also prepared and examined. The accompanying electron micrographs show the ascocarp pits and conidial surface spines. It was thought that these might be of interest

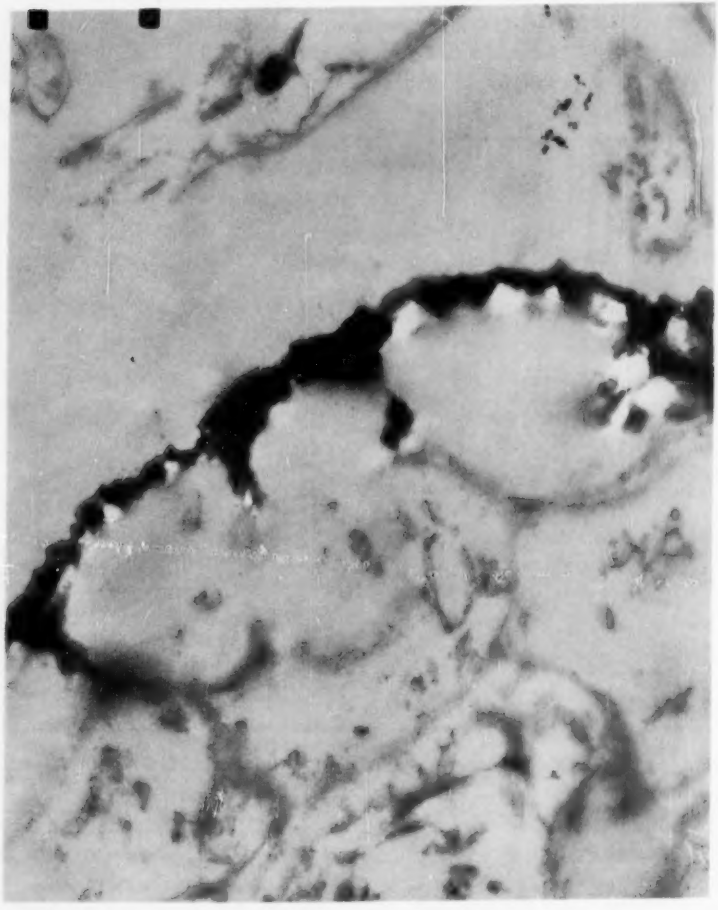

FIG. 2. *Thielavia sepedonium*, cross section of ascocarp wall showing the single celled outer layer. The outer wall is dense and thick, the inner wall thin. The cross walls that appear as ridges in light microscope extend inward, and the surface is covered with pits showing as thick and thin places.

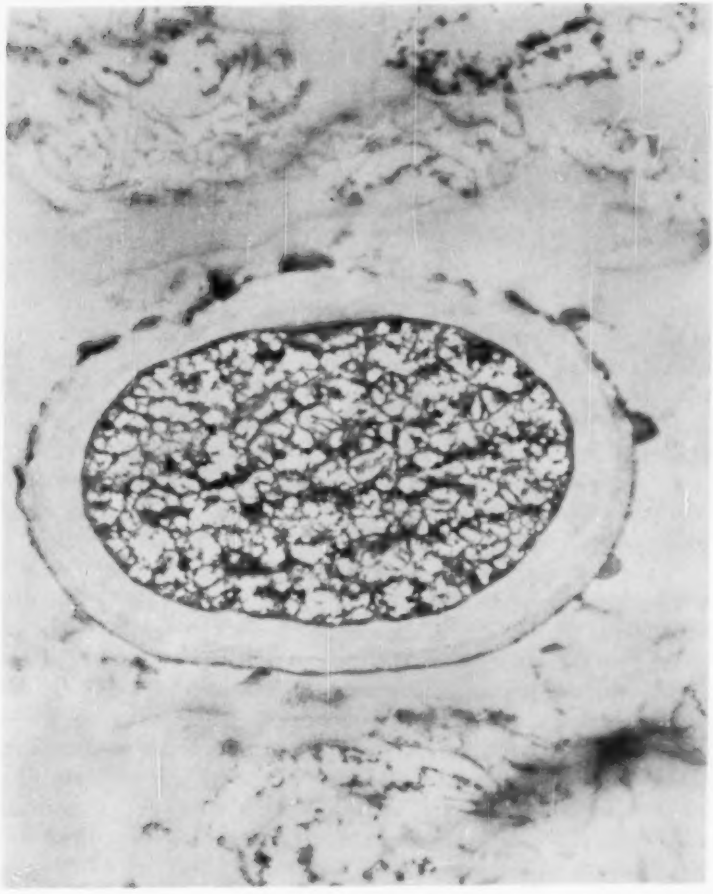

FIG. 3. *Thielavia sepedonium*, section through a conidium showing inner reticulum, the thick wall, and some of the prickles barely visible with light microscope.

to other observers.—L. W. DURRELL, Colorado State University, Fort Collins, Colorado.

LITERATURE CITED

1. **Emmons, C. W.** 1932. The development of the ascocarp in two species of *Thielavia*. Bull. Torrey Bot. Club **59**: 415–422.
2. **Dade, H. A.** 1938. New Gold Coast Fungi I. British Mycol. Soc. Trans. **21**: 16–28.

REVIEWS

MONOGRAPH OF MONOCHAETIA AND PESTALOTIA, by Emil F. Guba, vii + 342 p., 125 figs. Harvard University Press, Cambridge, Massachusetts. 1961. Price, $10.

Like other groups of fungi, the Deuteromycetes have been represented by far too-few comprehensive taxonomic treatments. The literature and descriptions of members of the class are often so scattered and fragmentary that bringing them together is no small task without the further complication of critically evaluating each specimen and species encountered. Guba's monograph of the *Pestalotia*-complex, therefore, involving a large number of species, varieties, hosts, substrata, and locality records is especially welcome. Culminating nearly forty years of study of the group by Dr. Guba, it is indeed a valuable contribution and fills a long-standing need.

Monograph of Monochaetia and Pestalotia is based, of course, on the two earlier papers by the author (Phytopathology **19**: 191–232, 1929; Mycologia **24**: 355–397, 1932) entitled "Monograph of the genus *Pestalotia*," but is a much expanded, broader treatment. After a brief introduction, various aspects of the group are presented in a series of short chapters entitled "nomenclature," "cultural studies," "pathological considerations," "ascigerous forms," and "appendages or setulae." The first traces the generic nomenclatural history, points out that the name *Monochaetia* needs to be conserved, and states the author's firm, conservative stand on the classification of the taxa. The others, although interesting and useful discussions, might well have been expanded to advantage. Here, as elsewhere, references are cited in the text, rather than grouped at the ends of the chapters or at the end of the book. Frequently, those not found in the early chapters may be located under the individual species concerned.

The early chapters are followed by a helpful, illustrated discussion on conidial morphology and use of the artificial keys presented for the identification of all 262 recognized species of *Monochaetia* and *Pestalotia*. The keys are not dichotomous, but are clearly organized and are based entirely on conidial characteristics, with emphasis on cell number, the number and color of the colored intermediate cells, the type and number of setulae, the size of the conidia, and the length of the setulae.

Their completeness and lack of dependence upon host and fruiting body structure make the keys invaluable in the identification of those strains known only in culture or as deterioration agents. The keys, generic descriptions, complete species descriptions, synonymy, hosts, specimens examined, critical notes, and discussions are contained in the two chapters *"Monochaetia"* and *"Pestalotia"* that comprise the major part of the book. Of 75 described, 41 species of *Monochaetia* are recognized as valid, including two species described as new and two new combinations. There are 221 species of *Pestalotia* recognized as valid, including 20 new species, 12 new combinations, and 3 new names. In both genera the species are arranged in sections termed Quadriloculatae, Quinqueloculatae, and Sexloculatae, and are profusely illustrated with line drawings of conidia.

Subsequent chapters, which deal with "Indefinite species of *Pestalotia*," "Excluded species" and "Miscellanea," contain a wealth of information on species that have been described as *Pestalotia* and ones that have some resemblance to the genus. A number of new combinations and reassignments are made here and two new genera, *Monoceras* and *Hyalotia*, described.

The book ends with a complete index of the scientific names of hosts and fungi. As an authoritative taxonomic treatise containing a great amount of precise, first-hand information that is concisely and orderly arranged, this monograph will be extremely useful to a large number of individuals.—C. R. BENJAMIN.

A PRELIMINARY STUDY OF THE INDIAN DISCOMYCETE FLORA, by Lekh Raj Batra, v + 47 p., duplicated. Swarthmore, Pennsylvania, 1960. Published by the author, 119 Diam Ganj., Amritsar, India, or Swarthmore College. Price, Rupees 6 ($1.75) to individuals; Rupees 8 ($2.50) to institutions.

Since the publication of Butler and Bisby's Fungi of India nearly thirty years ago, no comprehensive treatment of the Indian Discomycetes has been attempted. The present paper admirably fills the need for such a compilation. Admittedly a preliminary outline, to be used as a basis for future more complete studies, it brings together in the form of a check list all of the previously published records of the Discomycetes (operculate and inoperculate) from India and Pakistan, to which are

added the recent extensive collections made by the author and others. The genera are systematically arranged in accordance with modern taxonomic concepts and specific names revised to conform with the International Code of Botanical Nomenclature. Keys to genera and species, a bibliography and a glossary are included.

It seems ill-advised for the author to name and describe new species and propose new combinations in a work which, as he points out, does not constitute valid publication from a nomenclatorial standpoint. The numerous orthographic errors, though regrettable, detract only slightly from the value of this very useful paper.—E. K. CASH.

THE MOLDS AND MAN. AN INTRODUCTION TO THE FUNGI, by Clyde M. Christensen. 2nd ed. revised. viii + 238 p. University of Minnesota Press, Minneapolis, Minn. 15 May 1961. Paper $1.75; cloth $4.75.

Indicative of the demand for this popular treatment of the fungi is the appearance of a second revised edition just 10 years after the first (cf. Mycologia **44**: 156, 157. 1952). Chapters dealing with what fungi do, how they grow, their reproduction, their partnerships with other plants and with animals, their parasitism of plants, insects, animals and man, and their exploitation industrially are the same in both editions. Fourteen photographs have been added to the revision. The chapter on fungi in foods and building materials has been rewritten completely and brought up-to-date. A chapter on experiments with fungi has been added. Unfortunately, the appendix summarizing the classification of fungi has been deleted.

The book continues to be the best popular treatment of fungi.—CLARK T. ROGERSON.

FLORA ČSR—GASTEROMYCETES, HOUBY-BŘICHATKY (GASTEROMYCETES–PUFFBALLS). Edited by A. Pilát, Nakladatelstvi Československé Akademie věd, Praha, 862 pp. 256 figures. (In Czech with a Latin key) 1958. Price 87.50 Czech Crowns.

The comprehensive works by Hollós, Fischer, Cunningham, Zeller and Dodge and others are now supplemented by an equally complete

treatise of the Gastromycetes of a European country with a rich gastromycete flora, containing, aside from the current central European elements, some of the species known from the steppe regions of eastern Europe and some southern European elements. This volume is part of a large work, *The Flora of the Czechoslovac Republic,* edited by Dr. F. A. Novák and is the first contribution in the mycology-lichenology series with the collaboration of K. Cejp, Z. Moravec, A. Pilát, Z. Pouzar, V. J. Staněk, M. Svrček, S. Šebek, and F. Šmarda, whereby large parts of the treatment were contributed by each of these authors. The Flora is complete with a foreword, a "Conspectus systematicus," a general introduction and key to the orders, an index of literature, an index of Czech and Latin names, and of authors by A. Pilát who also wrote the entire taxonomic-floristic part on Phallales, Gautieriales, and Gastrosporiales. The Gastromycetes are treated as a class, with a subdivision inspired by Malençon (and based on the controversial phylogenetic speculations of the Heim-Malençon school of thought) into two subclasses Exogasteromycetidae, and Endogasteromycetidae, difficult to separate in the dichotomic key. Pilát admits ten orders: Phallales (Phallaceae, Clathraceae, Claustulaceae), Hysteriangiales (Hysterangiaceae by Svrček), Hymenogastrales (Rhizopogonaceae, Hymenogastraceae, Hydnangiaceae, all by Svrček), Gautierales (Gautieriaceae by Pilát), Gastrosporiales (Gastrosporiaceae by Pilát), Podaxales (Secotiaceae, Podaxaceae by Šebek), Lycoperdales (Arachniaceae by Moravec, Lycoperdaceae by Šmarda, Mycenastraceae by Šebek, Geastraceae by Staněk), Melanogastrales (Melanogastraceae by Svrček), Sclerodermatales (Sclerodermataceae by Šebek, Pisolithaceae and Glischrodermataceae by Pilát, Tulostomataceae by Moravec, *Tulostoma* by Pouzar, Calostomataceae by Pilát, Astraeaceae by Staněk), Nidulariales (Nidulariaceae and Sphaerobolaceae by Cejp). Apparently workable keys lead from higher taxa down to the species. The illustrations are adequate. We also find some area maps. Paper and binding are good and the number of printing errors moderate. With each order a separate literature list is included. The descriptions are, according to the method of the different authors, differently edited which, in addition to the difficulty in interpreting the meaning of Czech terms, makes the use of the descriptive data somewhat hazardous for most foreigners. Some descriptions lack a few of the data now considered essential in certain families, for example in *Hydnangium carneum* there is no indication of the presence of clamp connections and on the amyloidity of the spores. In the same species the sterigmata and the spore attachment are not described, and the basidia are indicated as measuring 18–20 × 10–13 μ,

instead of 26–51 × 7.5–12.5 μ. Such minor shortcomings of the descriptive parts can of course be excused in a large flora written for the purpose of giving the mycologist a tool for the determination of the Czech species rather than to provide modern data and new approaches to gastromycete systematics, inasmuch as the latest literature on some groups, particularly Secotiaceae, has appeared just after Pilát's work was edited. Furthermore, the treatment is generally quite up-to-date. Some genera are treated with a highly interesting fresh and original approach, whereby the respective authors propose new and often convincingly improved classifications. The type species of each genus are indicated and the rules of nomenclature are generally strictly observed, with few exceptions (as in *Tulostoma* where the new section *Brumalia* Pouzar should be sect. *Tulostoma*, and the sect. *Schizostoma* (see Saccardo 7: 3) should have been typified and used rather than abandoned if the rules as accepted in Paris were applied).

Even though some mycologists may disagree with one or another of the opinions expressed by the authors or with certain details of taxonomy, synonymy, etc., this attractive book will be of great help to those who attempt to work with or determine gastromycetes in Czechoslovakia, and even beyond its limits. Foreign readers will particularly benefit by the extensive (p. 702–827) keys in Latin; they will also appreciate the bilingual legends of the figures. The reader who knows Czech will particularly enjoy the interesting annotations and the data on the ecology of many species. Dr. Pilát and his collaborators may be congratulated for his successful effort to provide the mycologist with a valuable addition to the taxonomic literature.—ROLF SINGER.

THE BIOLOGY OF MYCORRHIZA, by J. L. Harley. Plant Science Monographs. xiv + 233 p., 14 text figs., 11 plates. Leonard Hall (Books) Ltd., London N.W.1, 1959. Price, 55 s.

Among the first publications in the two new series of Leonard Hill books "Plant Science Monographs" and "World Crops Books," both edited by Nicolas Polunin, we find three of particular interest for the mycologist, and the first one of these to appear is J. L. Harvey's book on mycorrhiza. Considering the growing interest and the large amount of papers now available in this field of research, the author's task to condense the whole subject of the biology of the mycorrhiza has been a

formidable one, and his sense of discrimination as to what material to include, what to illustrate, how far to go in generalizations must be highly commended. The choice was made under the assumption that the book should not be an attempt to supersede previous accounts on the subject, but a presentation of the subject in such a form as to interest the experimentally inclined biologists. This does not mean that the author has neglected entirely the hypotheses on the functioning of mycorrhizal organs as long as they were based on experiments, nor have possible practical applications in forestry and other applied fields been omitted, but they were put in separate chapters so as not to interfere with the basic presentation of verifiable facts. The book contains not only a review of the most pertinent published data, but also some unpublished experimental results by the author himself, and by Dr. T. H. Nicolson, Lilian Hawker, and F. W. Wilson. The author has successfully avoided the fallacy of discarding entirely the significance of the identity of the mycorrhizal fungi, so commonly found in some of his predecessors. This is of particular interest to those mycologists who are not primarily interested in the physiology of the mycorrhizal complex. The author states that the tree species with ectotrophic forest tree mycorrhiza (for which after the publication of Harley's book the term "ectotroph" has been accepted) "are usually dual organisms in the same sense as lichens are dual organisms." This statement coincides with the basic starting point of the most recent attempts to assay the importance of tree mycorrhiza in forest communities.

The text is divided into three parts: "General Considerations," "Ectotrophic Mycorrhizas" and "Endotrophic Mycorrhizas."

Each part consists of a number of chapters which are organized around the description of the various definable phenomena. Then the problem of fungus identity and mycorrhizal physiology is stated. This arrangement avoids many spurious generalizations only too frequently found in earlier accounts and emphasizes the wide margin that divides the near-parasitic unspecialized mycorrhiza fungi from the highly specialized and constant mycorrhizal relationship. The author has also been preoccupied—and justly so—with the difficulty of classifying mycorrhizal associations into natural kinds. He first attempts to relate them to other kinds of associations between microorganisms and higher plants not considered mycorrhizal, with pathological associations of root and fungus, and to casual associations which are almost general between soil microorganisms and plant organs imbedded in the soil. The endotrophic mycorrhizae, evidently most difficult to define as a single natural phe-

nomenon, are divided into "Mycorrhiza in the Ericales," "Mycorrhiza in the Orchidaceae," "Other mycotrophic plants with septate endophytes," and finally "Mycorrhizae caused by aseptate mycelia" (Phycomycetous mycorrhiza).

The illustrations, some of them in color, some of the black and white adapted from other publications, are clear and well reproduced. The text ends with a carefully selected bibliography of over 400 items and an author and subject index. The work is highly readable, clear, well balanced, easy to survey and to use. Mycologists will be grateful for this attractively presented book.—ROLF SINGER.

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Vol. 3, part 1, 1910. Nectriaceae-Fimetariaceae.

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Vol. 7 (now complete), parts 1–15, 1906–1940. Ustilaginaceae-Aecidiaceae.

Vol. 9 (now complete), parts 1–7, 1907–1916. Polyporaceae-Agaricaceae (pars).

Vol. 10, part 1, 1914; parts 2 and 3, 1917; part 4, 1924; part 5, 1932. Agaricaceae (pars).

Series II, part 1, 1934. Tuberales.

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